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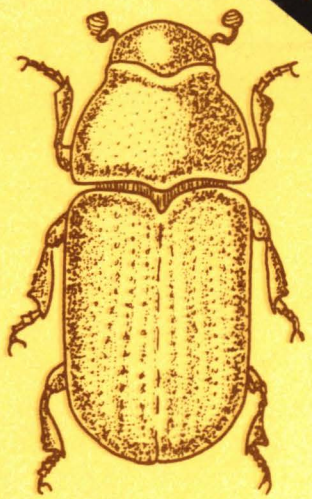
BIOLOGICAL EVALUATION
Western Spruce Budworm

National Forest, National
Park, Indian Reservation,
State, and Private Lands

Region 3

1978



Southwestern Region

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Region 3

1978

Forest Insect and Disease Management
State and Private Forestry
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TECHNICAL INFORMATION

Insect.--Western spruce budworm, Choristoneura occidentalis Freeman

Hosts.--Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco
White fir, Abies concolor (Gord. & Glend.) Lindl.
Subalpine fir, Abies lasiocarpa (Hook.) Nutt.
Blue spruce, Picea pungens Engelm.
Engelmann spruce, Picea engelmannii Parry

Location.--The following entomological units were sampled in 1978 (Fig. 1):

Gila Unit (Fig. 2).--Reserve RD, Gila NF - 10 clusters.

Jemez East Unit (Figs. 3 through 7).--Espanola RD and Tesuque RD, Santa Fe NF; Bandelier National Monument - 93 clusters.

Jemez West Unit (Figs. 8 through 15).--Cuba RD and Jemez RD, Santa Fe NF; Jemez Pueblo Indian Reservation - 147 clusters.

Jemez Central Unit (Figs. 16 through 18).--Cuba RD and Jemez RD, Santa Fe NF - 50 clusters.

Kaibab Unit (Figs. 19 and 20).--North Kaibab RD, Kaibab NF; North Rim, Grand Canyon National Park - 19 clusters.

Manzano Unit (Fig. 21).--Mountainair RD, Cibola NF - 16 clusters.

Sandia Unit (Fig. 22).--Sandia RD, Cibola NF - 20 clusters.

Questa Unit (Fig. 23).--Questa RD, Carson NF - 20 clusters.

Taos Unit (Fig. 24).--Taos RD, Carson NF; Taos Pueblo Indian Reservation - 20 clusters.

INTRODUCTION

Budworm populations in Region 3 were at endemic levels in 1974 (Acciavatti and Smith 1974). By 1975, the first signs of visible defoliation were detected on 9,853 acres (Table 1) of host type throughout the Region (Acciavatti 1975). In 1976, visible defoliation increased to 123,760 acres of host type (Acciavatti 1976). Visible defoliation increased for a third consecutive year in 1977 to 197,788 acres of host type. In addition to egg mass information, defoliation was measured beginning in 1977 on established tree clusters. In 1978, visible defoliation decreased to 78,535 acres of host type.

Table 1--Acres infested by western spruce budworm, 1974-1978.

	1974	1975	1976	1977	1978
Light	0	6,770	94,840	171,992	27,041
Moderate	0	2,381	26,080	23,716	38,352
Heavy	0	702	2,840	2,080	13,142
Total	0	9,853	123,760	197,788	78,535

Type of Damage.--Western spruce budworm larvae damage host trees by feeding on new foliage. Young larvae mine into the swelling buds and flowers in the spring. Large larvae continue feeding on the expanding new growth. As the larvae feed, they web shoots together. Needles on the webbed shoots become reddish brown by July and eventually fall from the tree. Indications are that moderate to heavy defoliation for 3 to 5 years may cause growth loss. If heavy defoliation continues, top-kill and tree mortality will occur.

Presently, two long-term evaluations are being conducted in Region 3 to determine the extent of growth loss, top-kill, and tree mortality due to this insect. The first of these evaluations was started in 1977 in the Jemez Mountains, Santa Fe National Forest (Parker, Acciavatti and Lessard 1978). The second evaluation was started in 1978 on the Carson National Forest (Lessard 1978).

METHODS

Region 3 has been divided into entomological units based on geographical location of contiguous host type and past history of budworm infestations. Aerial detection survey data from 1977 and 1978, on the extent and severity of defoliation, were used to determine which units should be included in the biological evaluation. Within each unit, 3-tree sampling clusters were established. The number of clusters per unit is shown under the Technical Information section. The Jemez East Unit was divided into four subunits and the Jemez Central Unit was divided into two subunits. These six subunits made up the unsprayed check area for a

suppression and evaluation spray project conducted in 1977. The Jemez West Unit was divided into six subunits and was aerially treated with carbaryl in 1977 (Parker, Acciavatti, and Lessard 1978).

Egg Mass.--Sampling was done during August 1978. Each cluster consisted of 3 trees within a 1-acre (.40 hectare) area. Sampled trees met the following criteria: Douglas-fir; dominant or codominant; 30 to 50 feet (9.1 to 15.2 meters) in height; relatively open-grown with a full crown; some feeding evident, but not severely defoliated or with top-kill. Two 27.5-inch (70 cm) midcrown branches were cut from opposite sides of each sample tree with a pole pruner. Each branch was then individually bagged in ¼-bushel (.03 cubic feet) paper sacks, sealed, labeled, and transported to the laboratory for examination. All sacks were stored in a walk-in cooler at about 40^{o} F (4.4^{o} C) prior to examination.

In the laboratory, the length and width of each branch was measured to obtain an estimate of the foliated branch surface area. Then, the foliage was examined under ultraviolet light for egg masses (Acciavatti and Jennings 1976). New egg masses (deposited in 1978) were separated from old ones (deposited before 1978) by an experienced laboratory technician. New egg masses were then separated into two categories: Greater than 50 percent parasitized and less than 50 percent parasitized.

Mean densities of 1977 and 1978 egg masses per square meter of foliage were calculated for each unit to determine infestation trend and predict defoliation expected in 1979. Infestation trend was based on testing the mean density difference between 1977 and 1978 egg masses with a "t" value ($P < .05$). Both increasing and decreasing infestation trends would have significant density differences from year to year, but an increasing trend would have a ratio of new (1978) to new (1977) egg masses greater than 1, while a decreasing trend would have a ratio of less than 1. A nonsignificant density difference would indicate a static infestation trend. Defoliation predictions were obtained from the density of 1978 egg masses using Table 2.

Defoliation.--The same tree clusters sampled for egg masses were sampled for defoliation. Sample branches consisted of 4 apical branches 27.5 inches in length taken from opposite quadrants at midcrown of each sample tree. From each of these branch samples, 25 new shoots were examined for current defoliation using the left side of one branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index and midpoint value as follows:

Table 2.--Class limits for western spruce budworm egg mass densities and defoliation classes (From: McKnight et al. 1970).

Egg mass density[1/]	Predicted defoliation class[2/]
< 1.55	Undetectable for all infestations
1.71 to 6.20	Undetectable for "static" infestations Light for "increasing" infestations
9.30 to 31	Light for "static" infestations Moderate for "increasing" infestations
> 34.10	Moderate for "static" infestations Heavy for "increasing" infestations

1/ New egg masses per square meter of foliage
2/ Defoliation class limits (percent of new growth)
Undetectable = < 5%
Light = 5 to 35%
Moderate = 35 to 65%
Heavy = > 65%

Defoliation class %	Index value	Midpoint value
0-25	1	12.5
26-50	2	37.5
51-75	3	62.5
76-100	4	87.5

Cluster level percent defoliation is simply the average of all 300 twiglets sampled on a particular cluster. Percent defoliation for the entomological unit is the average of all clusters sampled on the unit.

RESULTS AND DISCUSSION

Visible defoliation decreased in 1978. In 1977, visible defoliation was recorded on 197,788 acres compared to 78,535 acres in 1978. Defoliation estimates from permanently established clusters show that the aerial estimate of defoliation for 1978 was low. There were two reasons for this. First, less than 30 percent defoliation is undetectable during reconnaissance surveys. Defoliation for 1978 on clusters not located in areas mapped on aerial surveys averaged 29.3 percent. Of the 395 clusters sampled in 1978, 293 were outside the area of visible defoliation. In 1977, all clusters were located in areas of visible defoliation. Second, tree growth in 1978 was substantially greater than in 1977 due to favorable weather conditions. This increased growth masked much of the defoliation normally categorized as light in aerial surveys. A comparison of acres infested by defoliation intensity shows an increase in both the moderate and heavy classes of 14,636 and 11,062, respectively. Acres infested in the light defoliation class decreased by 144,951 acres.

Budworm populations have remained at high levels in the Southwestern Region for the fourth consecutive year. Egg mass survey data indicate static to increasing trends on all but the Gila, Sandia, and Jemez West Entomological Units.

Infestation trends and recommendations for dealing with the budworm infestation will be discussed by entomological unit. Recommendations will be based on the following alternatives:

1. Do nothing.
2. Insecticide treatment
3. Salvage logging
4. Individual tree treatment
5. Silvicultural treatment
6. Biological control
7. Combination of alternatives

Alternative 1.--Do nothing. If this alternative is selected, tree damages in 1979 must be accepted. Maximum and 1979 expected tree damages are listed below:

	Tree Damages	Percent	
		Max.	1979
1.	Growth loss	30	5
2.	Understory mortality	15	5-10
3.	Sawtimber mortality	5	1
4.	Top-kill	25	5
5.	Cone crop reduction	90	90
6.	Christmas tree use reduction	90	90

Alternative 2.--Insecticide treatment. The only chemical recommended for aerial application against the western spruce budworm is carbaryl. For maximum effectiveness, the entire infestation should be treated. Treating only a portion of the infestation is not recommended. By treating the entire infestation, tree damages can be prevented through the remainder of this infestation cycle.

Alternative 3.--Salvage logging. This approach can be used for utilizing trees killed or damaged by the budworm. Salvage logging would have no effect on the trend of the infestation.

Alternative 4.--Individual tree treatment. Individual trees can be treated from the ground with chemical insecticides to prevent budworm defoliation. High-value trees in campgrounds, near visitor centers, etc., can be treated to prevent unsightly defoliation. Individual tree treatment would have no effect on the trend of the infestation. Trees will have to be treated at least every 2 years through the remainder of this infestation cycle.

Alternative 5, silvicultural control, is not a viable alternative at this time. Research information on silvicultural control of western spruce budworm in the Southwest is inadequate.

Alternative 6, biological control, is not a viable alternative for operational use. The bacterium Bacillus thuringiensis is not registered by the EPA for application against the western spruce budworm. This bacterium is the only biological showing promise as a control agent. More research is needed. There may be opportunities for field and pilot tests in Region 3 under the joint Canada-USA (CANUSA) Budworms Research Development and Applications Program.

Alternative 7.--Combination of alternatives. Any number of alternatives, depending on local conditions, can be used in response to this infestation.

Any chemical treatment should meet the following criteria:

1. Effective - suppress insect populations and reduce damages
2. Economical - benefits exceed costs
3. Environmentally sound - no irretrievable losses

Gila Entomological Unit

Current Infestation Trend.--Visible defoliation was first detected on 6,480 acres in 1976 (Table 3). The infestation remained static in 1977 with visible defoliation on 6,480 acres. By 1978, visible defoliation dropped to an undetectable level (Fig. 2).

The 1978:1977 egg mass ratio is 0.33:1, indicating a further decrease in the budworm population level for 1979. Defoliation should be undetectable over the entire unit in 1979.

Recommendation.--Because of the decreasing population trend for 1979, alternative 1, do nothing, is recommended for the Gila Entomological Unit.

Jemez East Entomological Unit

Current Infestation Trend.--Visible defoliation was first detected on 4,960 acres in 1976 (Table 4). In 1977, visible defoliation increased to 58,428 acres. Most of the defoliation in 1977 (97 percent) was classified as light. By 1978, visible defoliation decreased to 3,812 acres (13 percent in the moderate and 0 percent in the heavy classifications) (Figs. 3-7).

The 1978:1977 egg mass ratio is 0.91:1, indicating static infestation trend for 1979. Defoliation should be light over most of the unit in 1979.

Recommendation.--Because the infestation is static with only light defoliation predicted in 1979, alternative 1, do nothing, is recommended for the Jemez East Entomological Unit.

Jemez West Entomological Unit

Current Infestation Trend.--Visible defoliation was first detected on 12,440 acres in 1976 (Table 5). In June of 1977, this unit was treated with carbaryl. Visible defoliation decreased in 1977 to 2,175 acres. No visible defoliation was detected in 1978 (Figs. 8-15).

The 1978:1977 egg mass ratio is 0.24:1, indicating a further decreasing trend for 1979. Defoliation should be undetectable over the entire unit in 1979.

Table 3.--Gila Entomological Unit.

Egg Mass - Defoliation Survey

	1976	1977	1978
No. Clusters	10	10	10
new egg masses per m^2 of foliage	9.9	10.5	3.5
parasitized egg masses (%) [1/]			-0-
buildup ratio [2/]	1.19:1 [4/]	1.06:1	0.33:1
infestation trend	static to increasing	static	decreasing
actual defoliation (acres) [3/] L	4,160	4,160	0
M	2,320	2,320	0
H	0	0	0
unit defoliation (%)		56.8	20.6
predicted 1979 defoliation			undetectable

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
- L = light
- M = moderate
- H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

Table 4.--Jemez East Entomological Unit.

Egg Mass - Defoliation Survey

	1976	1977	1978
No. Clusters	10	97	93
new egg masses per m^2 of foliage	16.9	12.7	12.1
parasitized egg masses (%) 1/			4.3
buildup ratio 2/	2.4:1 4/	0.75:1	0.91:1
infestation trend	increasing	decreasing	static
actual defoliation (acres) 3/ L	2,520	56,872	3,309
M	2,440	1,556	503
H	0	0	0
unit defoliation (%)		44.8	29.3
predicted 1979 defoliation			light

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
L = light
M = moderate
H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

Table 5.--Jemez West Entomological Unit.

Egg Mass - Defoliation Survey

	1976	1977	1978
No. Clusters	11	150	147
new egg masses per m^2 of foliage	12.6	1.7	0.5
parasitized egg masses (%) 1/			0.0
buildup ratio 2/	1.84:1 4/	0.13:1	0.24:1
infestation trend	increasing	decreasing	decreasing
actual defoliation (acres) 3/ L	8,400	1,894	0
M	3,800	281	0
H	240	0	0
unit defoliation %		26.5	2.9
predicted 1979 defoliation			undetectable

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
L = light
M = moderate
H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

Recommendation.--Because the infestation is decreasing for the second consecutive year, alternative 1, do nothing, is recommended for the Jemez West Entomological Unit.

Jemez Central Entomological Unit

Current Infestation Trend.--Visible defoliation was first detected on 1,024 acres in 1977 (Table 6). In 1978, visible defoliation decreased slightly to 930 acres (45 percent in the moderate and 0 percent in the heavy classifications) (Figs. 16-18).

The 1978:1977 egg mass ratio is 1.42:1, indicating an increasing infestation trend for 1979. Defoliation should be undetectable in the Ojitos subunit and light to moderate in the Lake Fork subunit in 1979.

Recommendation.--Though the infestation trend is increasing, serious tree damage is not expected in the Jemez Central Entomological Unit in 1979. Also, this unit is part of a long-term western spruce budworm suppression and evaluation project. For these reasons, alternative 1, do nothing, is recommended for the Jemez Central Entomological Unit.

San Pedro Parks Wilderness

In the northern portion of the San Pedro Parks Wilderness, visible defoliation was first detected on 100 acres in 1976. Visible defoliation increased in 1977 to 3,220 acres in the San Pedro Parks Wilderness and adjoining Coyote Ranger District: 320 acres were classified as moderately defoliated and 2,900 as lightly defoliated. By 1978, the infestation increased to 3,943 acres (102 acres lightly defoliated, 2,074 moderately defoliated, and 1,767 heavily defoliated). Because the greater portion of the infestation is located in the wilderness, an entomological unit was not established. The infestation trend in the Jemez Central Unit would most closely approximate the trend in the wilderness. An increasing infestation trend in the northern portion of the San Pedro Parks Wilderness is predicted for 1979. Defoliation should be moderate to heavy over about the northern one third of the wilderness. Control is not recommended.

Kaibab Entomological Unit

Current Infestation Trend.--Visible defoliation was first detected on 781 acres in 1975. By 1976, visible defoliation increased to 67,320 acres (Table 7). Visible defoliation increased to 70,720 acres in 1977. Although visible defoliation decreased in 1978 to 39,501 acres, 63 percent of the acres defoliated were in the moderate to heavy class (Figs. 19 and 20).

Table 6.--Jemez Central Entomological Unit.

Egg Mass - Defoliation Survey

		1976	1977	1978
No. Clusters		-0-	50	50
new egg masses per m^2 of foliage			4.3	6.1
parasitized egg masses (%) [1/]				0.0
buildup ratio [2/]			3.92:1 [4/]	1.42:1
infestation trend			increasing	increasing
actual defoliation (acres) [3/]	L	0	435	512
	M	0	589	418
	H	0	0	0
unit defoliation (%)			32.6	25.3
predicted 1979 defoliation				light

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey

L = light
M = moderate
H = heavy

4/ Based on the ratio of new egg masses 1977: old egg masses 1977

Table 7.--Kaibab Entomological Unit.

Egg Mass - Defoliation Survey

		1976	1977	1978
No. Clusters		10	20	19
new egg masses per m^2 of foliage		17.6	28.4	31.8
parasitized egg masses (%) [1/]				4.9
buildup ratio [2/]		0.92:1 [4/]	1.61:1	1.07:1
infestation trend		static to decreasing	increasing	static
actual defoliation (acres) [3/]	L	62,840	64,400	14,515
	M	4,080	5,920	19,021
	H	400	400	5,965
unit defoliation (%)			45.9	61.5
predicted 1979 defoliation				moderate

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
- L = light
- M = moderate
- H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

The 1978:1977 egg mass ratio is 1.07:1, indicating a static infestation trend. The high number of new (1978) egg masses per m^2 of foliage (Table 7) indicates that defoliation over a large portion of the Kaibab Entomological Unit should be moderate to heavy in 1979.

Recommendation.--Because of the severity of defoliation predicted for 1979, alternatives 1, 2, or 7 are recommended.

Alternative 1.--Do nothing. If this alternative is selected, tree damages in 1979 must be accepted.

Alternative 2.--Insecticide treatment. If this alternative is selected, the entire infestation, including both the Grand Canyon National Park and Kaibab National Forest, should be treated. By treating the entire infestation, tree damages can be prevented through the remainder of this infestation cycle.

Alternative 7.--Combination of alternatives. If this alternative is selected, alternatives 1, 3, and 4 are recommended.

Manzano Entomological Unit

Current Infestation Trend.--Visible defoliation was first detected on 1,065 acres in 1975. By 1976, visible defoliation increased to 5,080 acres (Table 8). Visible defoliation again increased to 10,480 acres in 1977. Although visible defoliation decreased in 1978 to 5,064 acres, 52 percent of the acres defoliated were in the moderate to heavy class (Fig. 21).

The 1978:1977 egg mass ratio is 1.41:1, indicating an increasing infestation trend. The high number of new (1978) egg masses per m^2 of foliage (Table 8) indicates that the greater portion of defoliation in 1979 will be classified as moderate.

Recommendation.--Because of the wilderness status in the Manzano Mountains, alternative 1, do nothing, is recommended.

Sandia Entomological Unit

Current Infestation Trend.--In 1975, 360 acres of visible defoliation were detected on the Sandia Entomological Unit. By 1976, visible defoliation increased to 10,920 acres (Table 9). Visible defoliation increased slightly to 11,480 acres in 1977. Although visible defoliation decreased to 3,934 acres in 1978, 83 percent of the acres defoliated were in the moderate to heavy class (Fig. 22).

Table 8.--Manzano Entomological Unit.

Egg Mass - Defoliation Survey

	1976	1977	1978
No. Clusters	10	19	16
new egg masses per m^2 of foliage	17.5	14.4	17.1
parasitized egg masses (%) 1/			3.9
buildup ratio 2/	1.53:1 4/	0.82:1	1.14:1
infestation trend	increasing	decreasing	increasing
actual defoliation (acres) 3/ L	1,320	8,440	860
M	3,440	1,240	1,557
H	320	800	2,647
unit defoliation (%)		62.6	36.0
predicted 1979 defoliation			moderate

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
L = light
M = moderate
H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

Table 9.--Sandia Entomological Unit.

Egg Mass - Defoliation Survey

		1976	1977	1978
No. Clusters		10	20	20
new egg masses per m^2 of foliage		16.3	4.4	2.6
parasitized egg masses (%) 1/				-0-
buildup ratio 2/		1.01:1 4/	0.27:1	0.59:1
infestation trend		static	decreasing	decreasing
actual 3/ defoliation (acres)	L	6,200	10,000	676
	M	3,400	920	547
	H	1,320	560	2,711
unit defoliation (%)			61.9	17.5
predicted 1979 defoliation				undetectable

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
L = light
M = moderate
H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

The 1978:1977 egg mass ratio is 0.59:1, indicating a further decrease in the budworm population level. Defoliation should be undetectable over the entire unit for 1979.

Recommendation.--Because of the decreasing population trend for 1979, alternative 1, do nothing, is recommended for the Sandia Entomological Unit.

Questa and Taos Entomological Units

Current Infestation Trend (Questa Entomological Unit).--Visible defoliation was first detected in 1976 on 2,220 acres of the Questa Entomological Unit. By 1977, visible defoliation increased to 14,360 acres (Table 10). Although visible defoliation decreased in 1978 to 5,274 acres, 51 percent of the acres infested were in the moderate to heavy class (Fig. 23).

The 1978:1977 egg mass ratio is 1.75:1, indicating an increasing infestation trend. The high number of new (1978) egg masses per m^2 of foliage (Table 10) indicates that the greater portion of defoliation in 1979 will be classified as moderate.

Current Infestation Trend (Taos Entomological Unit).--Visible defoliation was first detected in 1975 on 520 acres of the Taos Entomological Unit. By 1976, visible defoliation increased to 16,560 acres (Table 11). In 1977, visible defoliation increased to 25,840 acres. Although visible defoliation decreased in 1978 to 9,765 acres, 72 percent of the acres infested were in the moderate to heavy class (Fig. 24).

The 1978:1977 egg mass ratio is 1.60:1, indicating an increasing infestation trend. The high number of new (1978) egg masses per m^2 of foliage (Table 11) indicates that a large portion of the defoliation in 1979 will be classified as heavy.

Recommendations.--Because of the severity of defoliation predicted for 1979, alternatives 1, 2, or 7 are recommended.

Alternative 1.--Do nothing. If this alternative is selected, tree damages in 1979 must be accepted.

Alternative 2.--Insecticide treatment. If this alternative is selected, the entire entomological unit should be treated. The Taos Entomological Unit includes both the Taos Ranger District and Taos Pueblo lands. The Questa Entomological Unit includes the Questa Ranger District.

Alternative 7.--Combination of alternatives. If this alternative is selected, alternatives 1, 3, and 4 are recommended.

Table 10.--Questa Entomological Unit.

Egg Mass - Defoliation Unit

	1976	1977	1978
No. Clusters	-0-	20	20
new egg masses per m^2 of foliage		9.9	17.9
parasitized egg masses (%) [1/]			3.6
buildup ratio [2/]		3.36:1 [4/]	1.75:1
infestation trend		increasing	increasing
actual defoliation (acres) [3/] L	1,920	13,080	2,560
M	300	960	2,330
H	0	320	384
unit defoliation (%)			46.9
predicted 1979 defoliation			moderate

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
L = light
M = moderate
H = heavy

4/ Based on the ratio of new egg masses 1977: old egg masses 1977

Table 11.-- Taos Entomological Unit.

Egg Mass - Defoliation Survey

	1976	1977	1978
No. Clusters	10	20	20
new egg masses per m^2 of foliage	38.3	22.3	38.5
parasitized egg masses (%) 1/			7.4
buildup ratio 2/	1.69:1 4/	0.58:1	1.60:1
infestation trend	increasing	decreasing	increasing
actual defoliation (acres) 3/ L	9,400	15,040	2,725
M	6,600	10,800	2,790
H	560	0	4,250
unit defoliation (%)		81.5	54.6
predicted 1979 defoliation			heavy

1/ New egg masses parasitized greater than 50%

2/ Based on the ratio of new egg masses in survey year: new egg masses previous year

3/ Determined from aerial reconnaissance survey
- L = light
- M = moderate
- H = heavy

4/ Based on the ratio of new egg masses 1976: old egg masses 1976

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A P P E N D I X

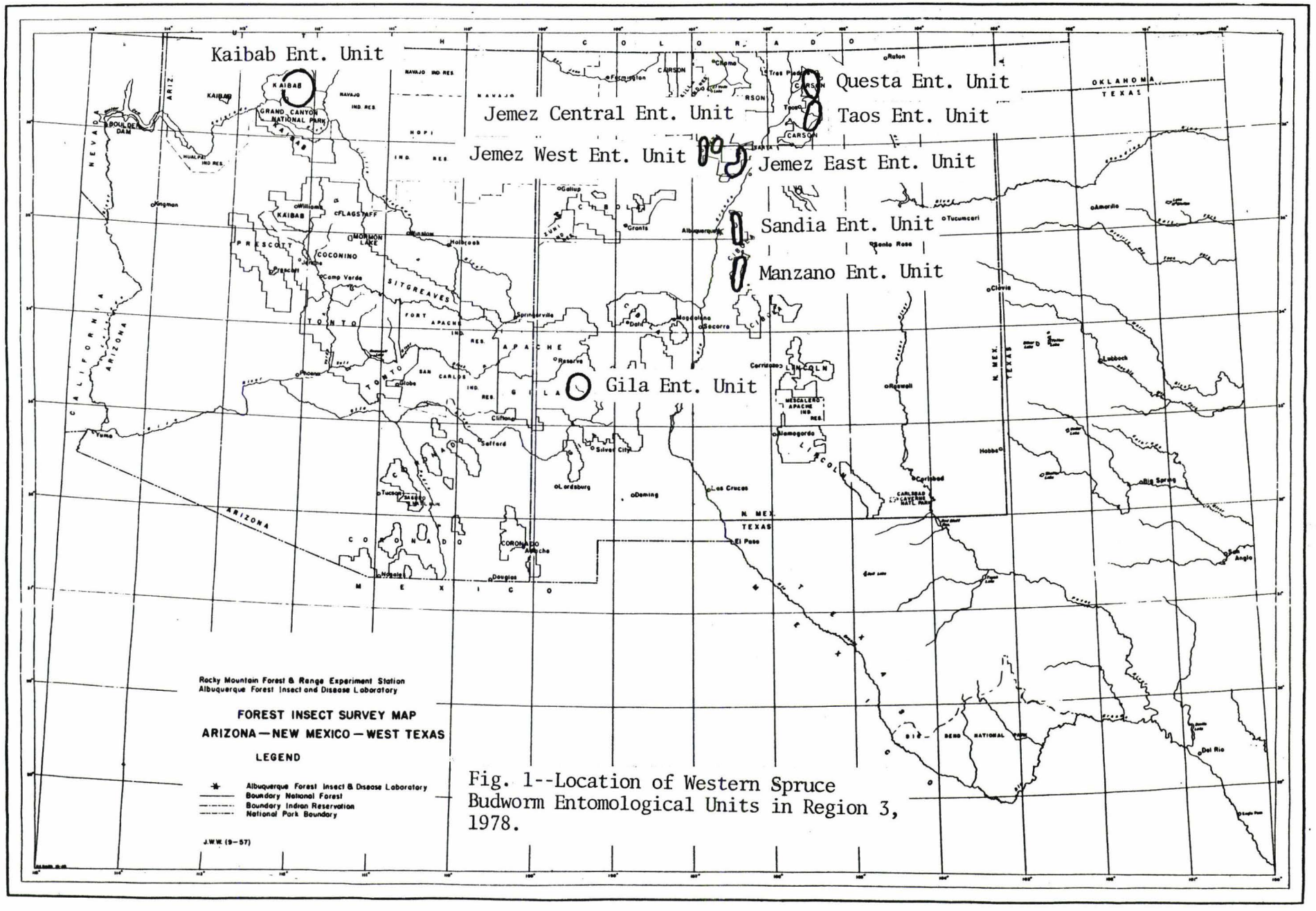


Fig. 1--Location of Western Spruce Budworm Entomological Units in Region 3, 1978.

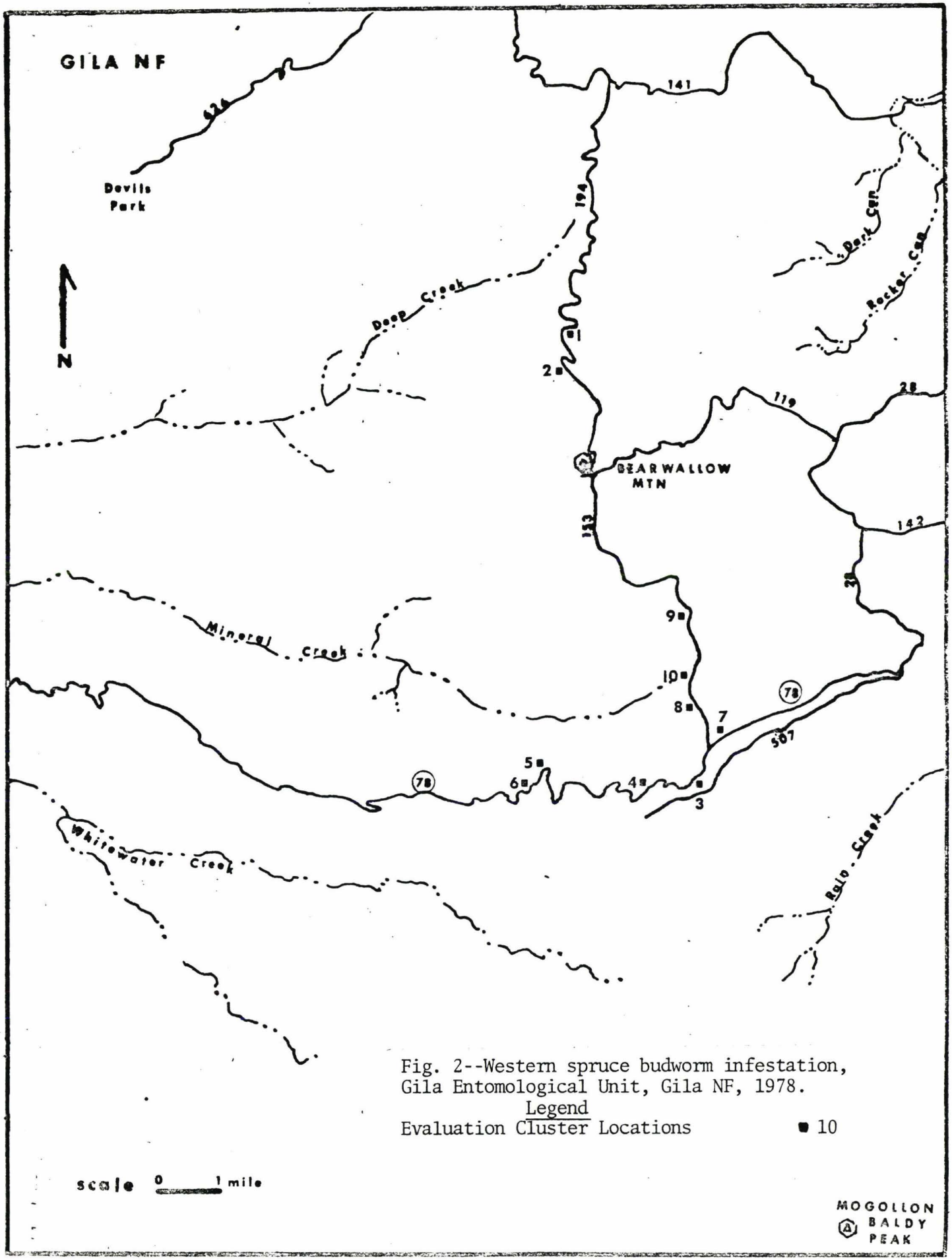
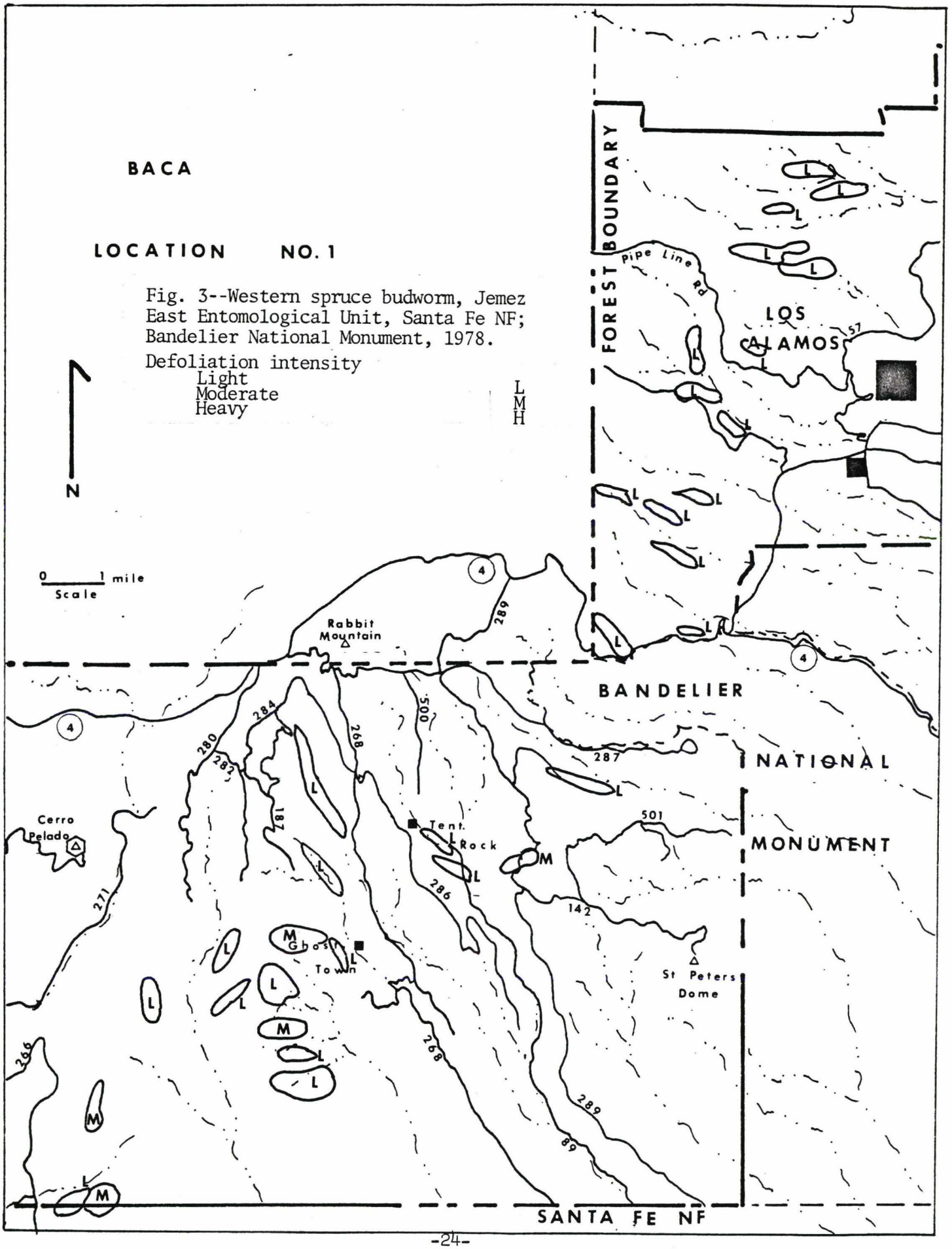


Fig. 2--Western spruce budworm infestation, Gila Entomological Unit, Gila NF, 1978.

Legend

Evaluation Cluster Locations ■ 10


BACA
LOCATION NO. 1
Fig. 3--Western spruce budworm, Jemez East Entomological Unit, Santa Fe NF; Bandelier National Monument, 1978.
Defoliation intensity
Light L
Moderate M
Heavy H
N
0 1 mile
Scale
FOREST BOUNDARY
Pipe Line Rd
LOS ALAMOS
57
Rabbit Mountain
BANDELIER
NATIONAL
MONUMENT
Cerro Pelado
Tent Rock
St Peters Dome
Town
SANTA FE NF

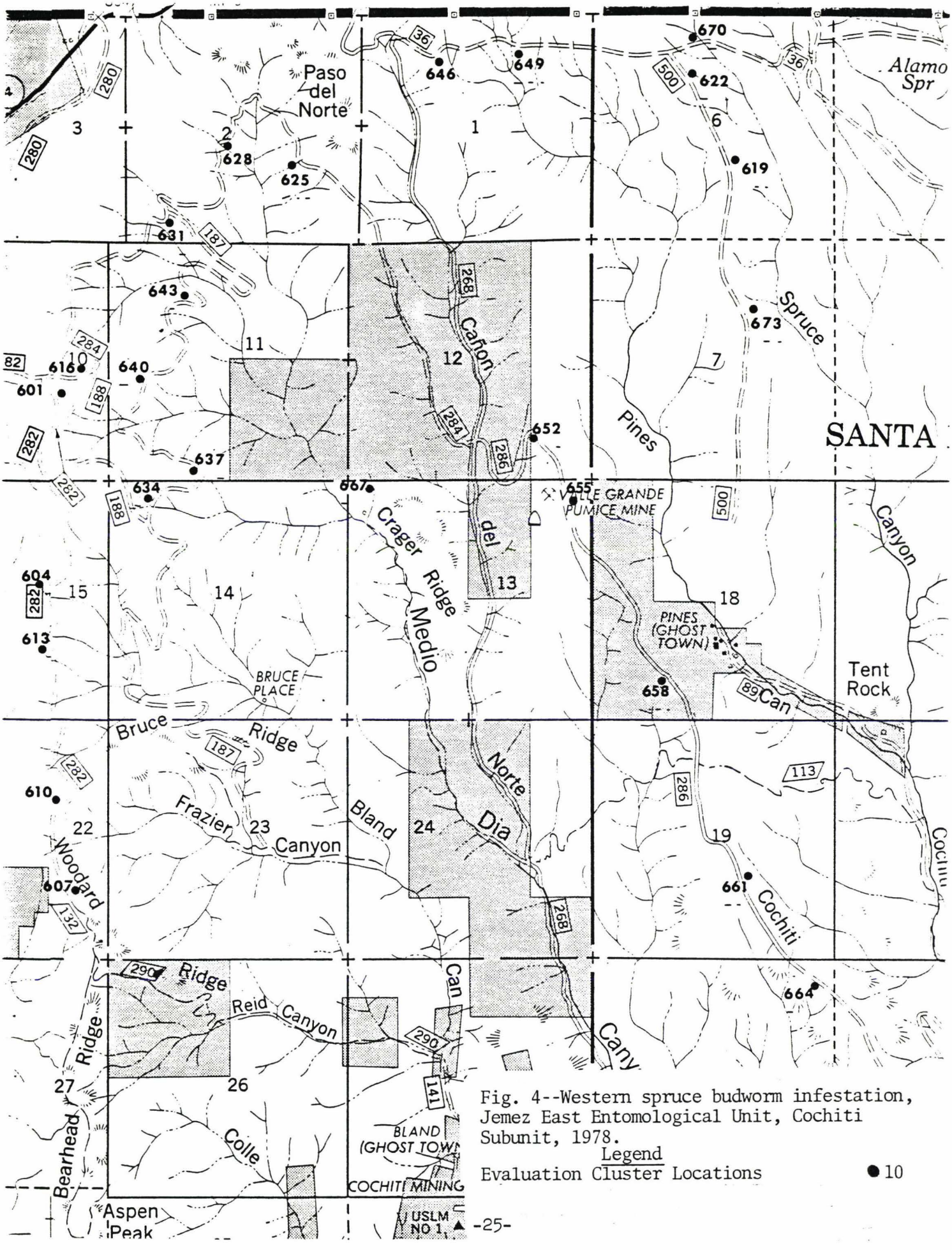


Fig. 4--Western spruce budworm infestation, Jemez East Entomological Unit, Cochiti Subunit, 1978.

Legend

Evaluation Cluster Locations ● 10

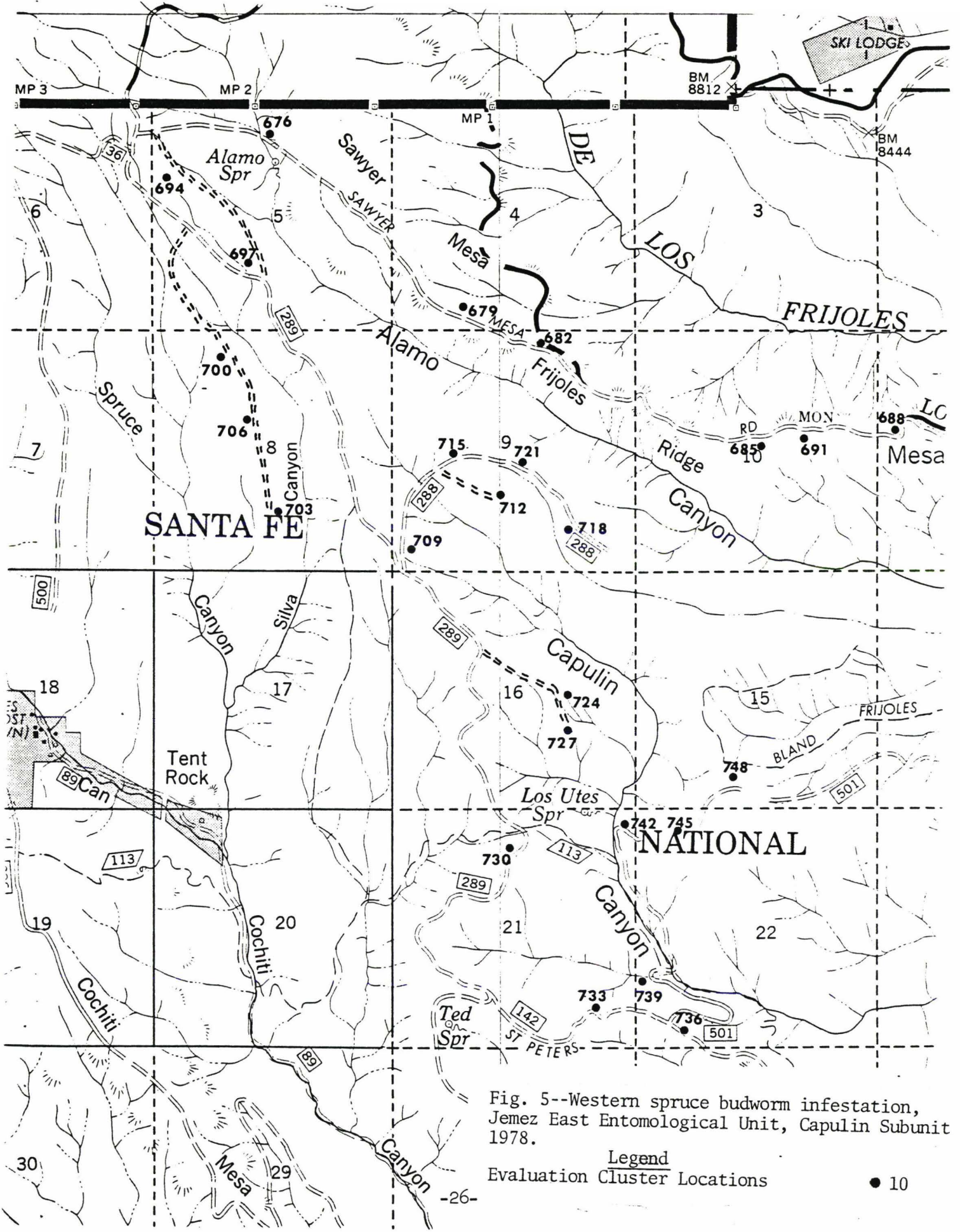


Fig. 5--Western spruce budworm infestation, Jemez East Entomological Unit, Capulin Subunit 1978.

Legend

Evaluation Cluster Locations ● 10

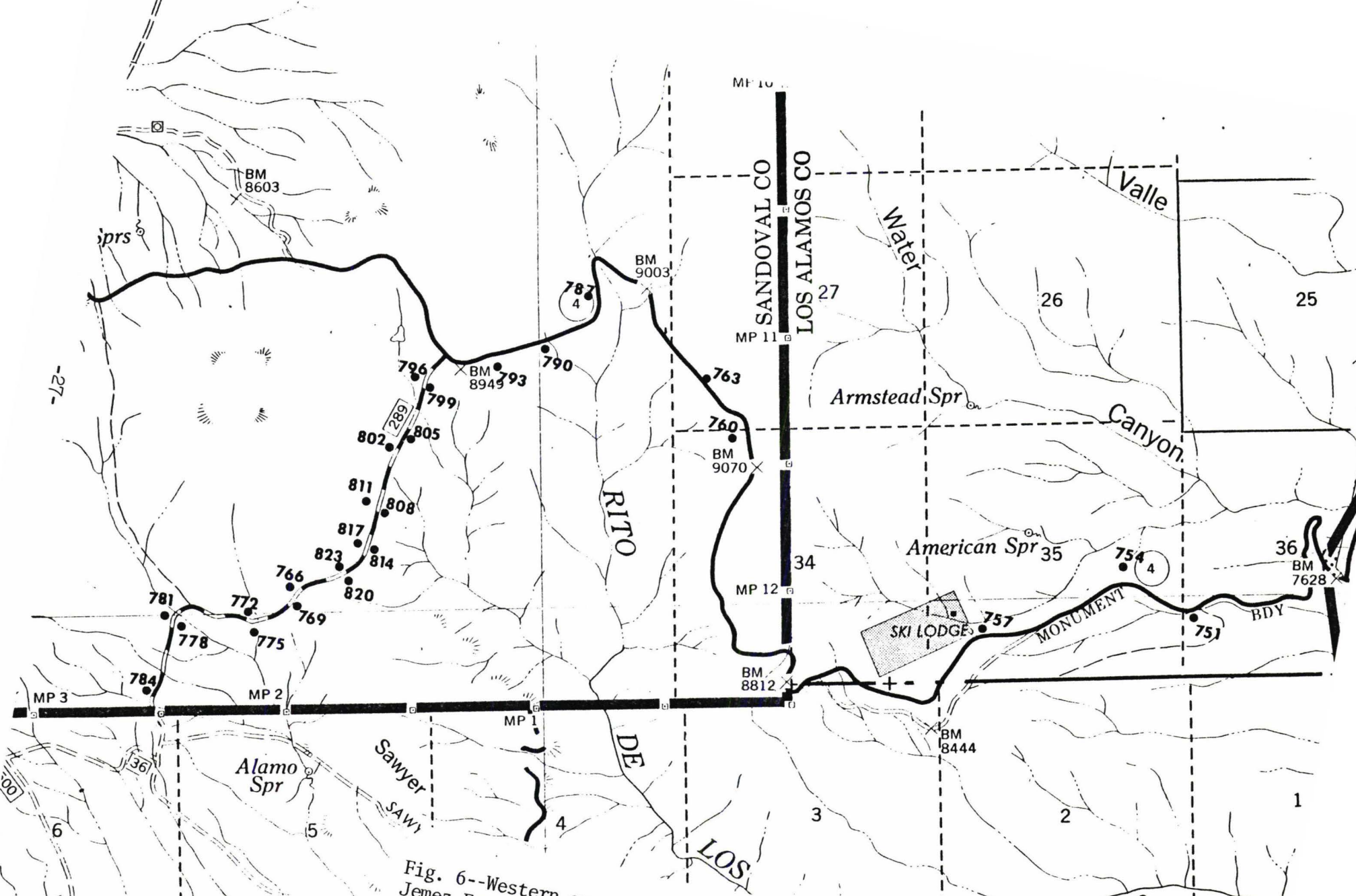


Fig. 6--Western spruce budworm infestation, Jemez East Entomological Unit, American Springs Subunit, 1978.

Legend

Evaluation Cluster Locations

●10

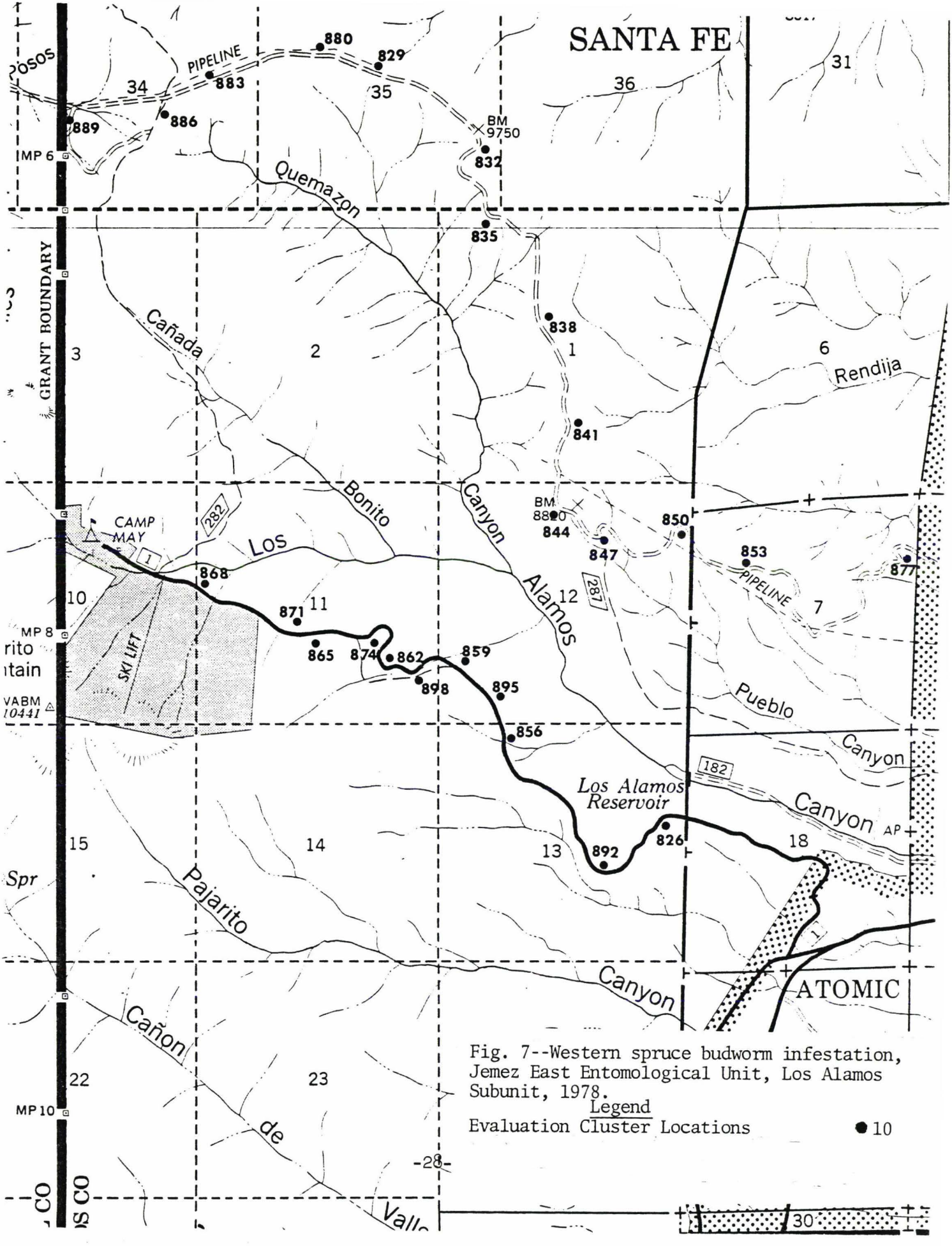


Fig. 7--Western spruce budworm infestation, Jemez East Entomological Unit, Los Alamos Subunit, 1978.

Legend

Evaluation Cluster Locations ● 10

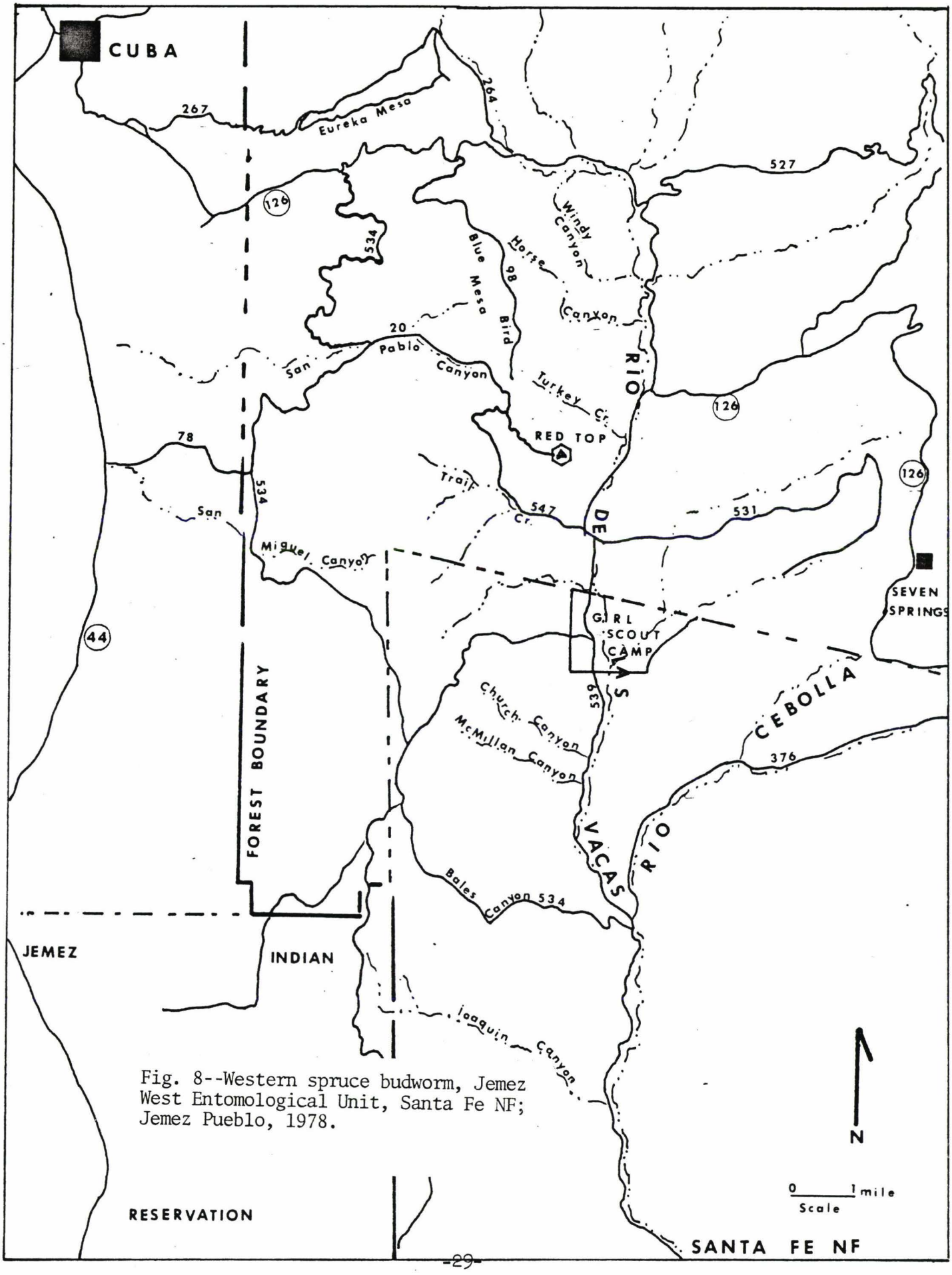


Fig. 8--Western spruce budworm, Jemez West Entomological Unit, Santa Fe NF; Jemez Pueblo, 1978.

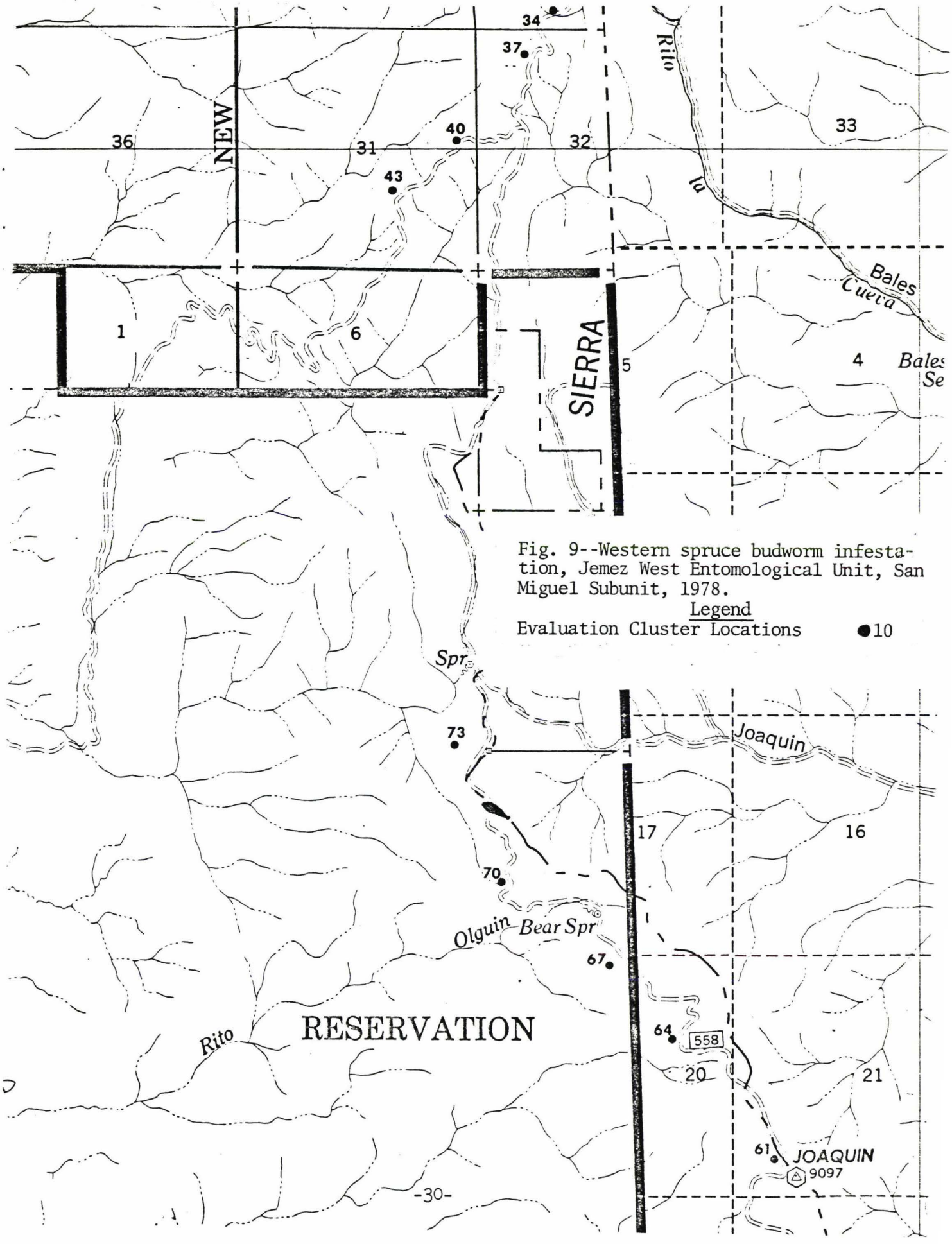


Fig. 9--Western spruce budworm infestation, Jemez West Entomological Unit, San Miguel Subunit, 1978.

Legend

Evaluation Cluster Locations ●10

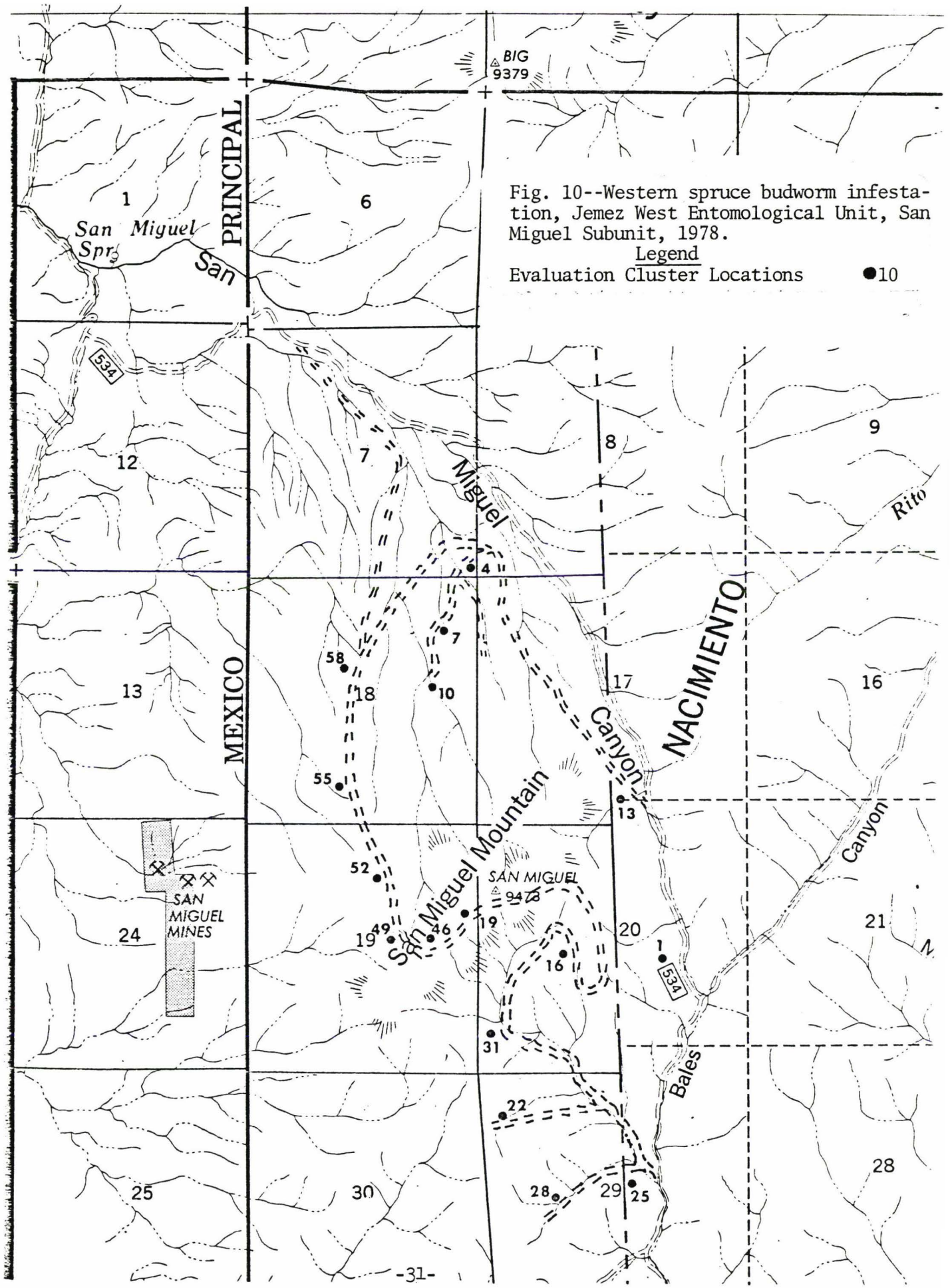


Fig. 10--Western spruce budworm infestation, Jemez West Entomological Unit, San Miguel Subunit, 1978.

Legend

Evaluation Cluster Locations ●10

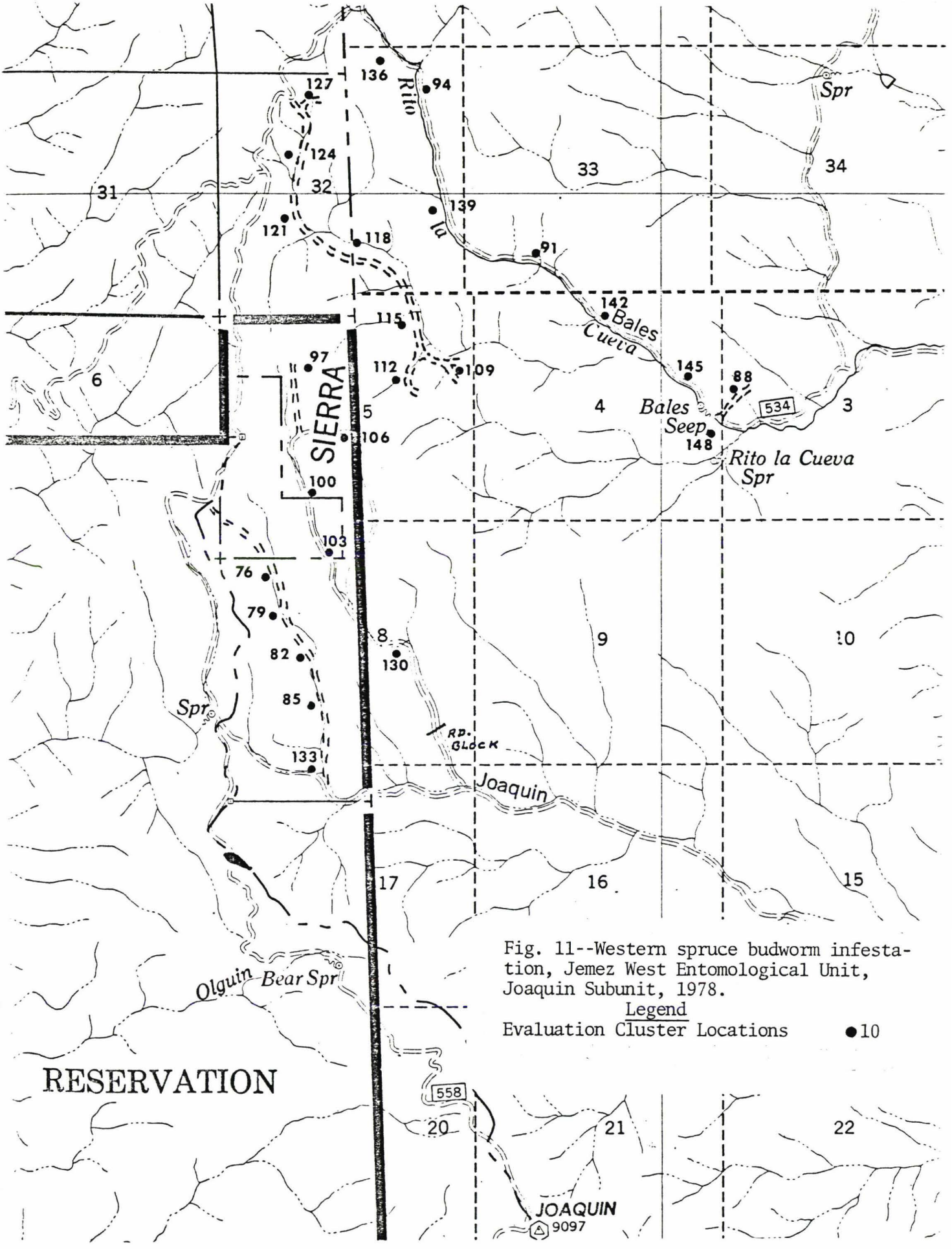


Fig. 11--Western spruce budworm infestation, Jemez West Entomological Unit, Joaquin Subunit, 1978.

Legend

Evaluation Cluster Locations ●10

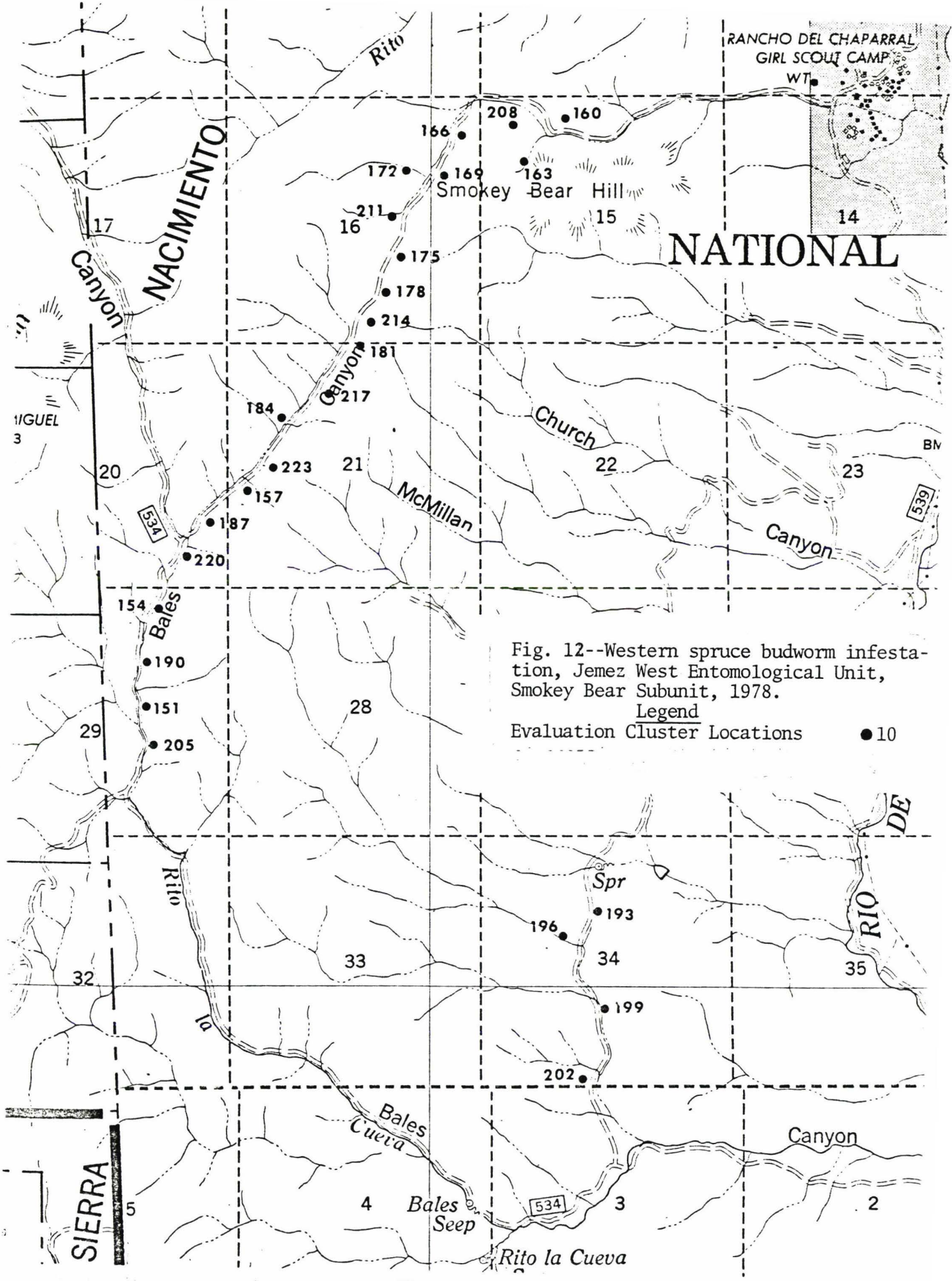


Fig. 12--Western spruce budworm infestation, Jemez West Entomological Unit, Smokey Bear Subunit, 1978.

Legend

Evaluation Cluster Locations ●10

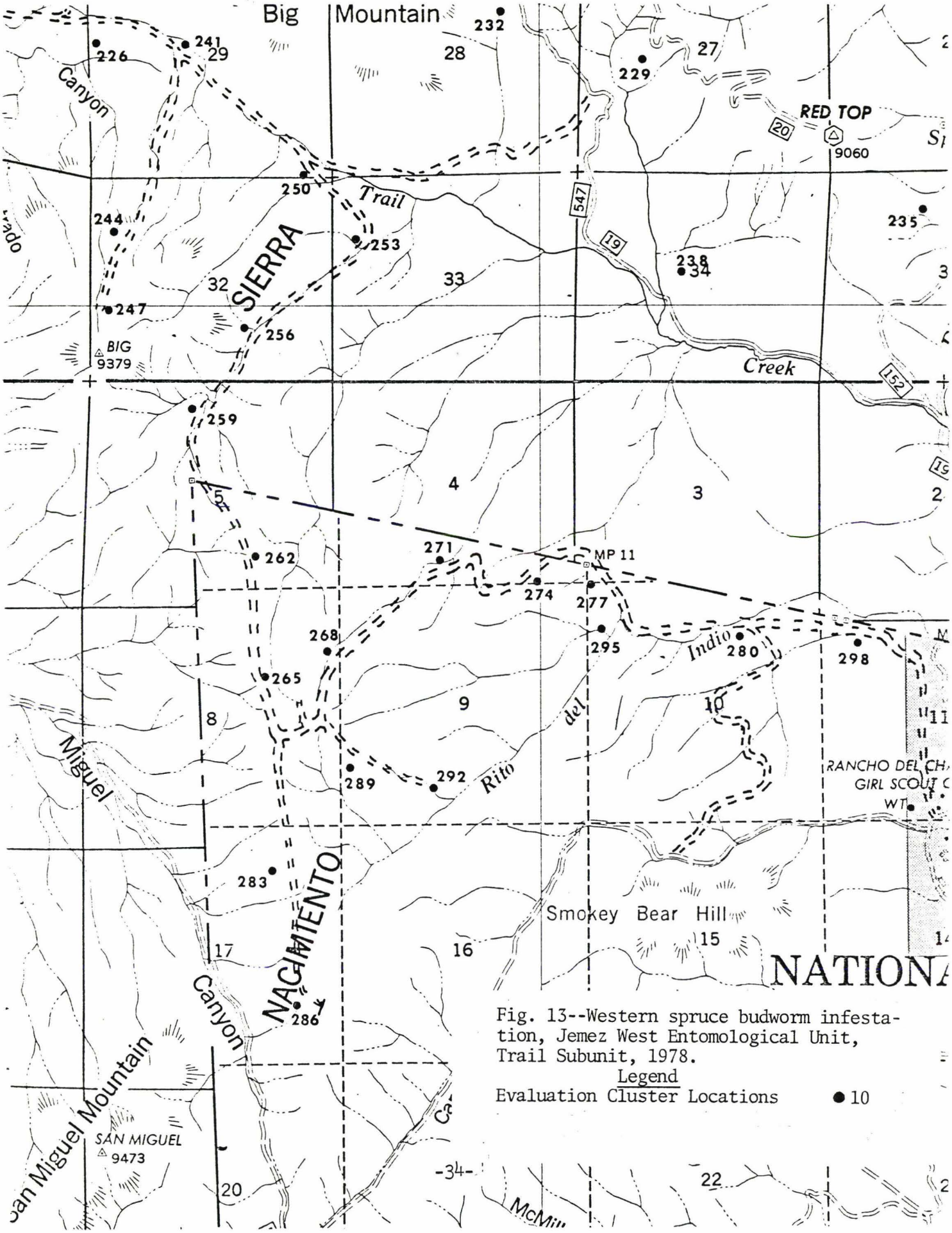


Fig. 13--Western spruce budworm infestation, Jemez West Entomological Unit, Trail Subunit, 1978.

Legend

Evaluation Cluster Locations ● 10

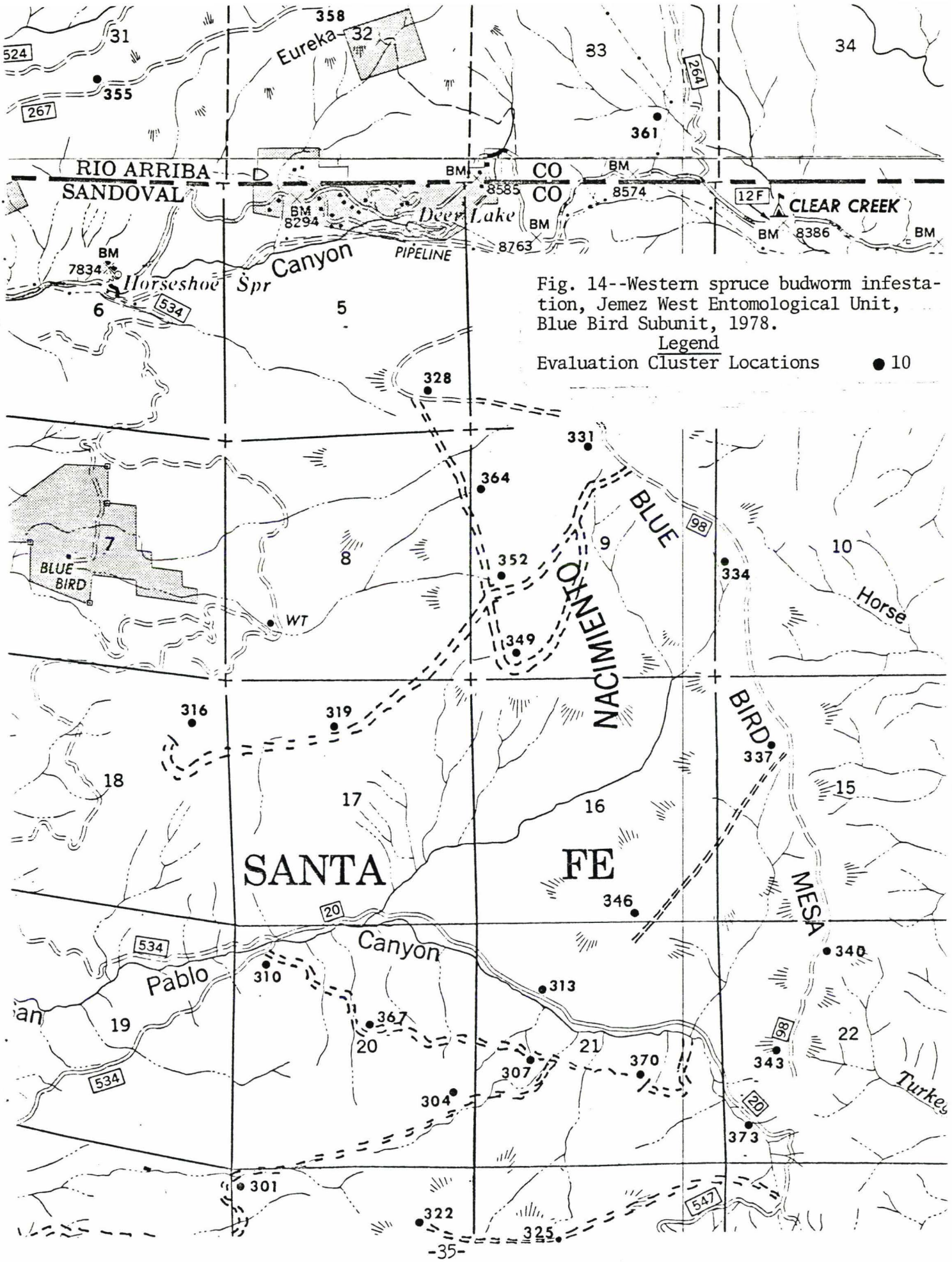
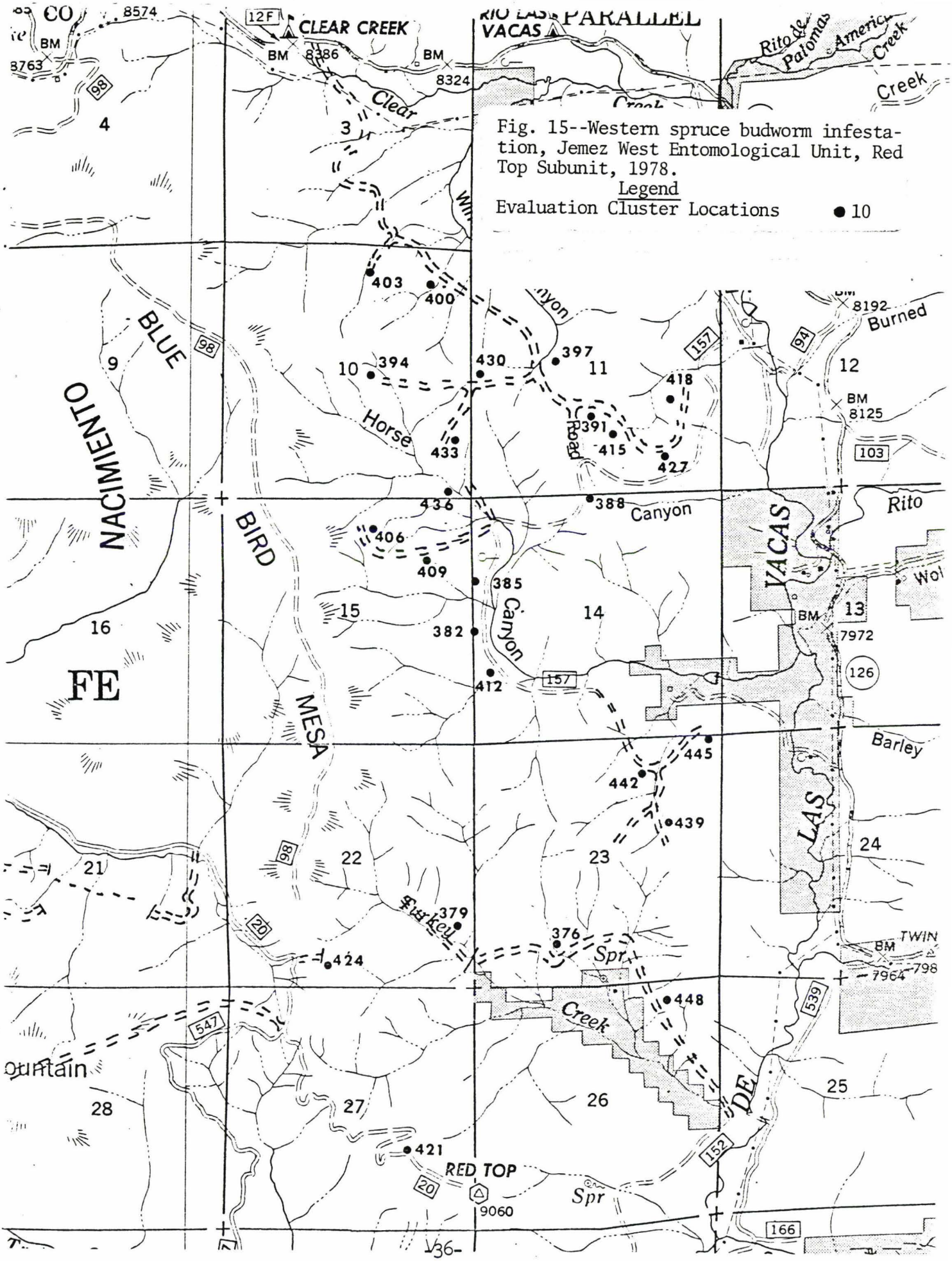


Fig. 14--Western spruce budworm infestation, Jemez West Entomological Unit, Blue Bird Subunit, 1978.

Legend

Evaluation Cluster Locations ● 10


CO
8574
12F
CLEAR CREEK
BM
8386
BM
8324
BM
3763
98
4
3
Clear
RIO LAS VACAS PARALLEL
Rito de Palomas
America Creek
Creek
Legend
Evaluation Cluster Locations ● 10
403
400
BLUE
NACIMIENTO
9
10
394
430
397
11
418
391
415
427
Horse
Road
433
157
94
8192
Burned
12
BM
8125
103
436
388
Canyon
Rito
406
409
385
BIRD
MESA
15
14
16
382
412
Canyon
VACAS
BM
13
7972
126
FE
445
442
439
Barley
LAS
22
23
24
21
20
379
376
424
Spr
TWIN
BM
7964
798
448
Creek
539
547
28
27
26
25
421
RED TOP
20
9060
Spr
152
166

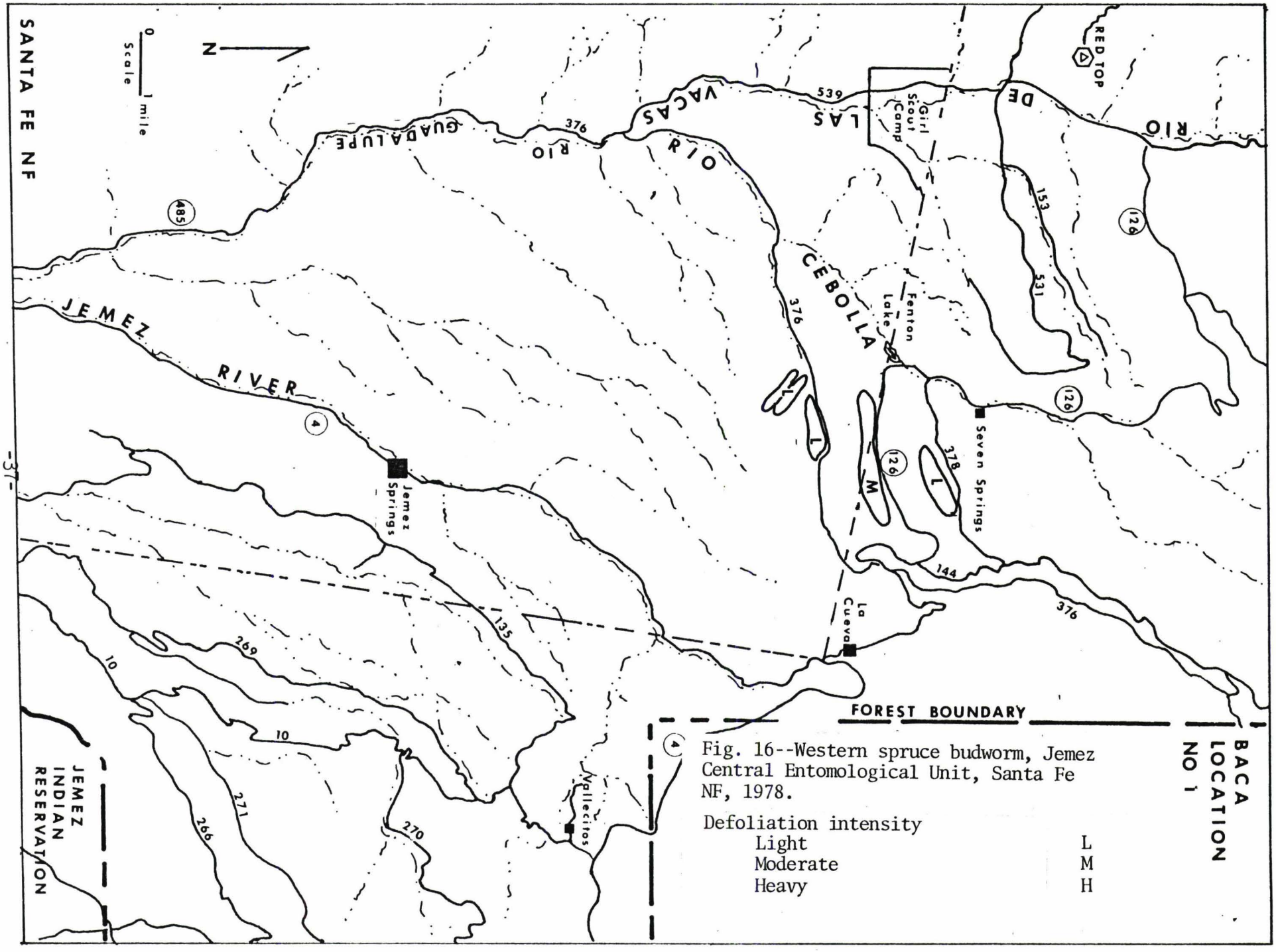


Fig. 16--Western spruce budworm, Jemez Central Entomological Unit, Santa Fe NF, 1978.

Defoliation intensity

Light	L
Moderate	M
Heavy	H

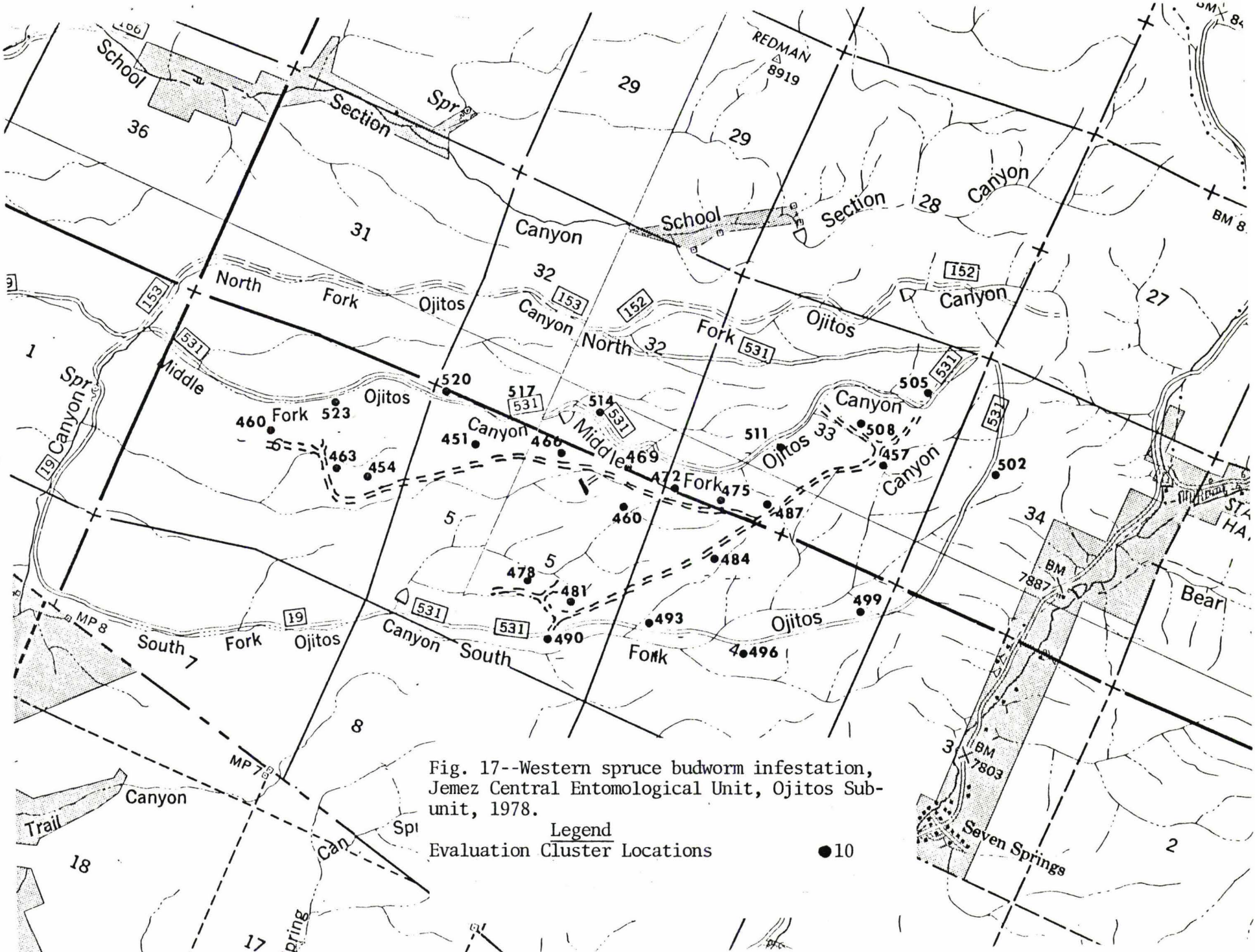


Fig. 17--Western spruce budworm infestation, Jemez Central Entomological Unit, Ojitos Subunit, 1978.

Legend

Evaluation Cluster Locations ●10

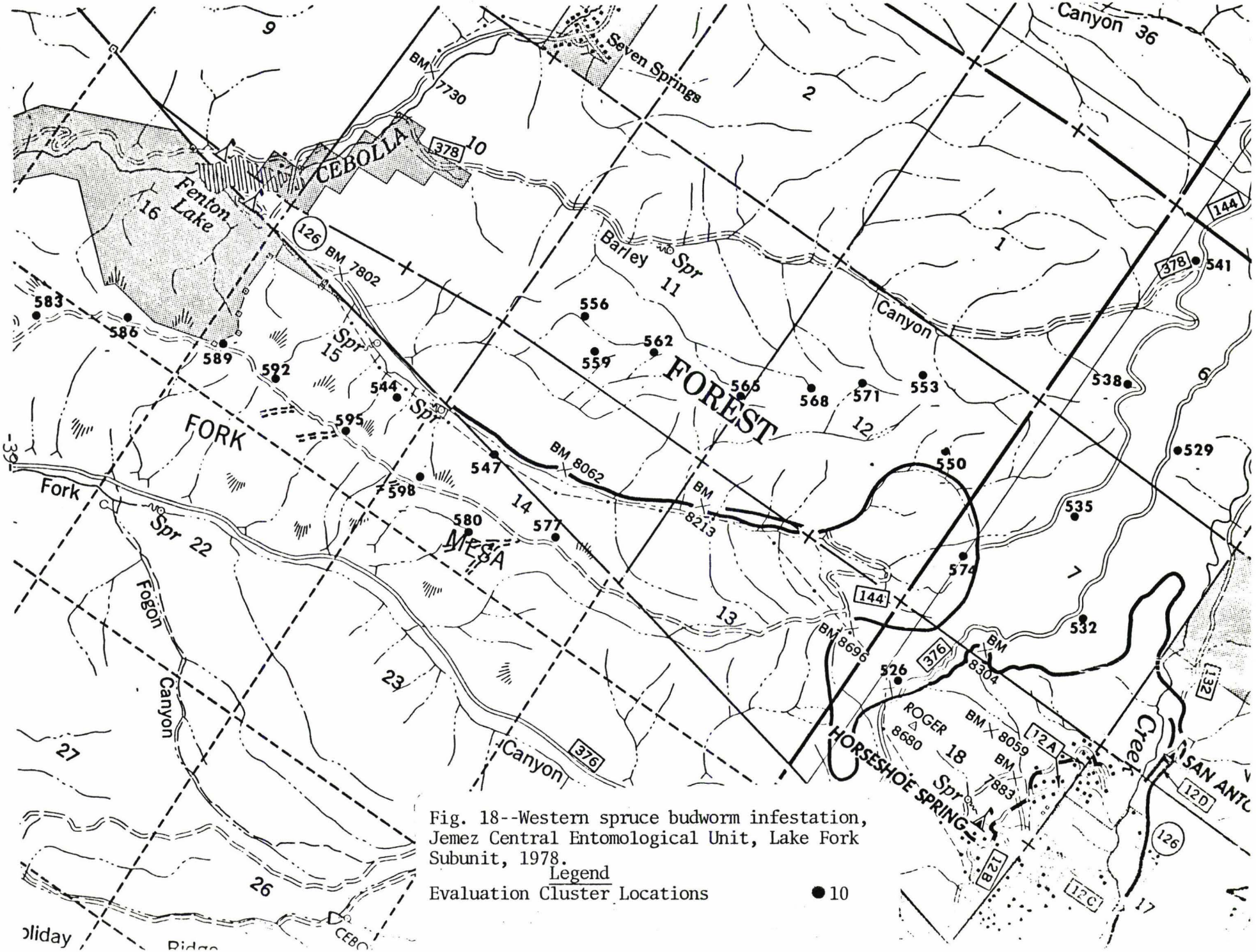


Fig. 18--Western spruce budworm infestation, Jemez Central Entomological Unit, Lake Fork Subunit, 1978.

Legend

Evaluation Cluster Locations ● 10

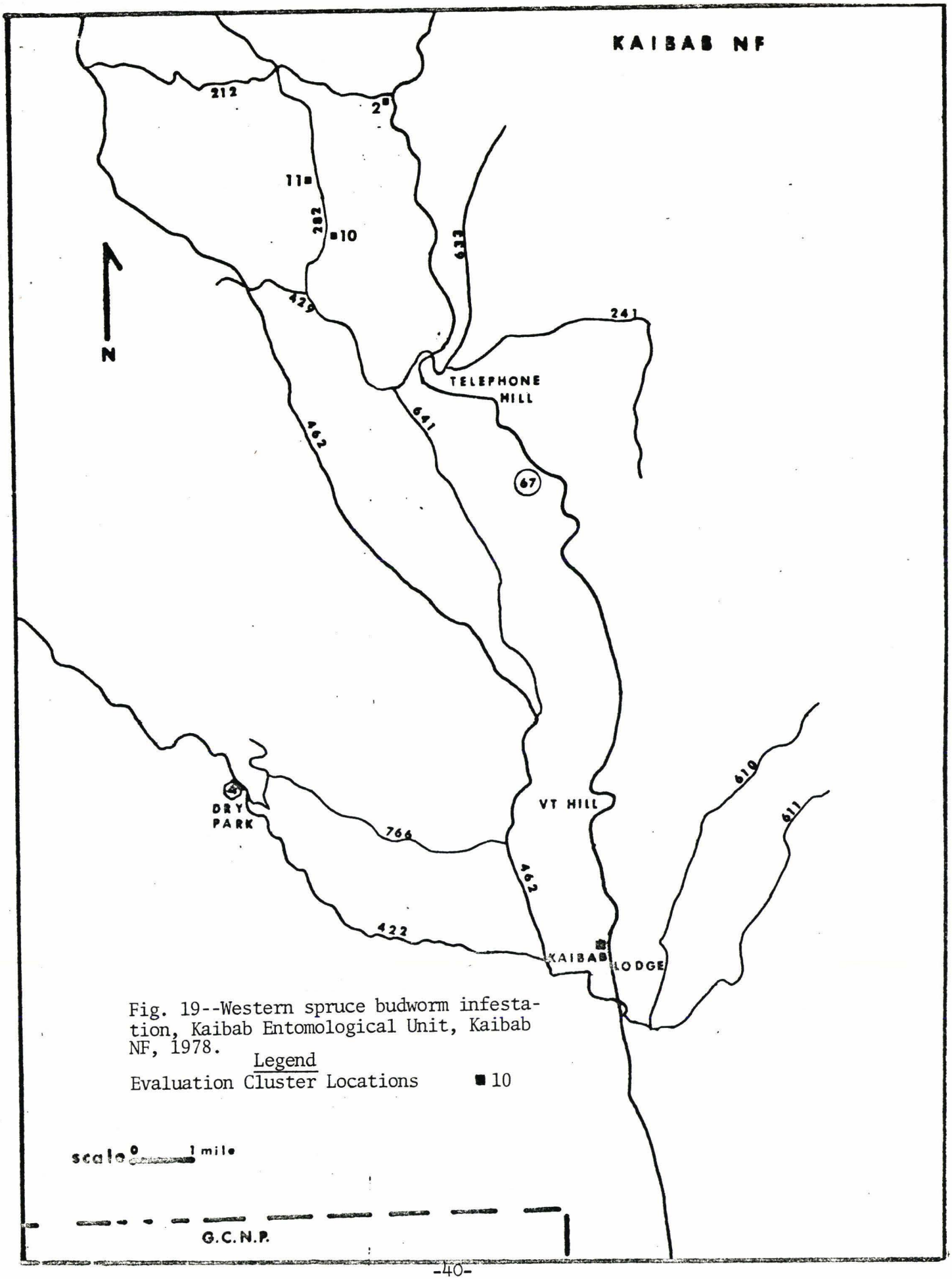


Fig. 19--Western spruce budworm infestation, Kaibab Entomological Unit, Kaibab NF, 1978.

Legend

Evaluation Cluster Locations ■ 10

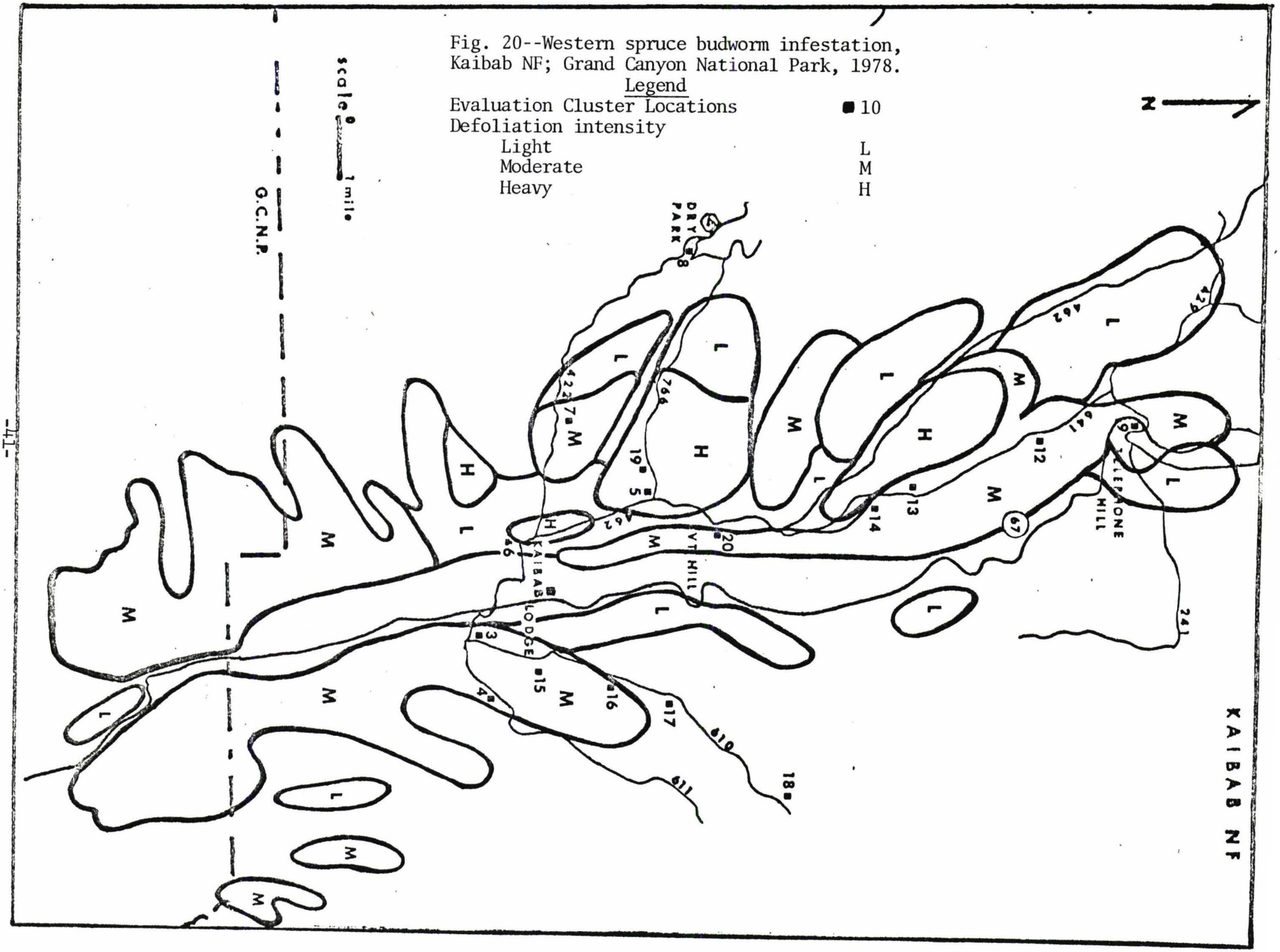


Fig. 20--Western spruce budworm infestation, Kaibab NF; Grand Canyon National Park, 1978.

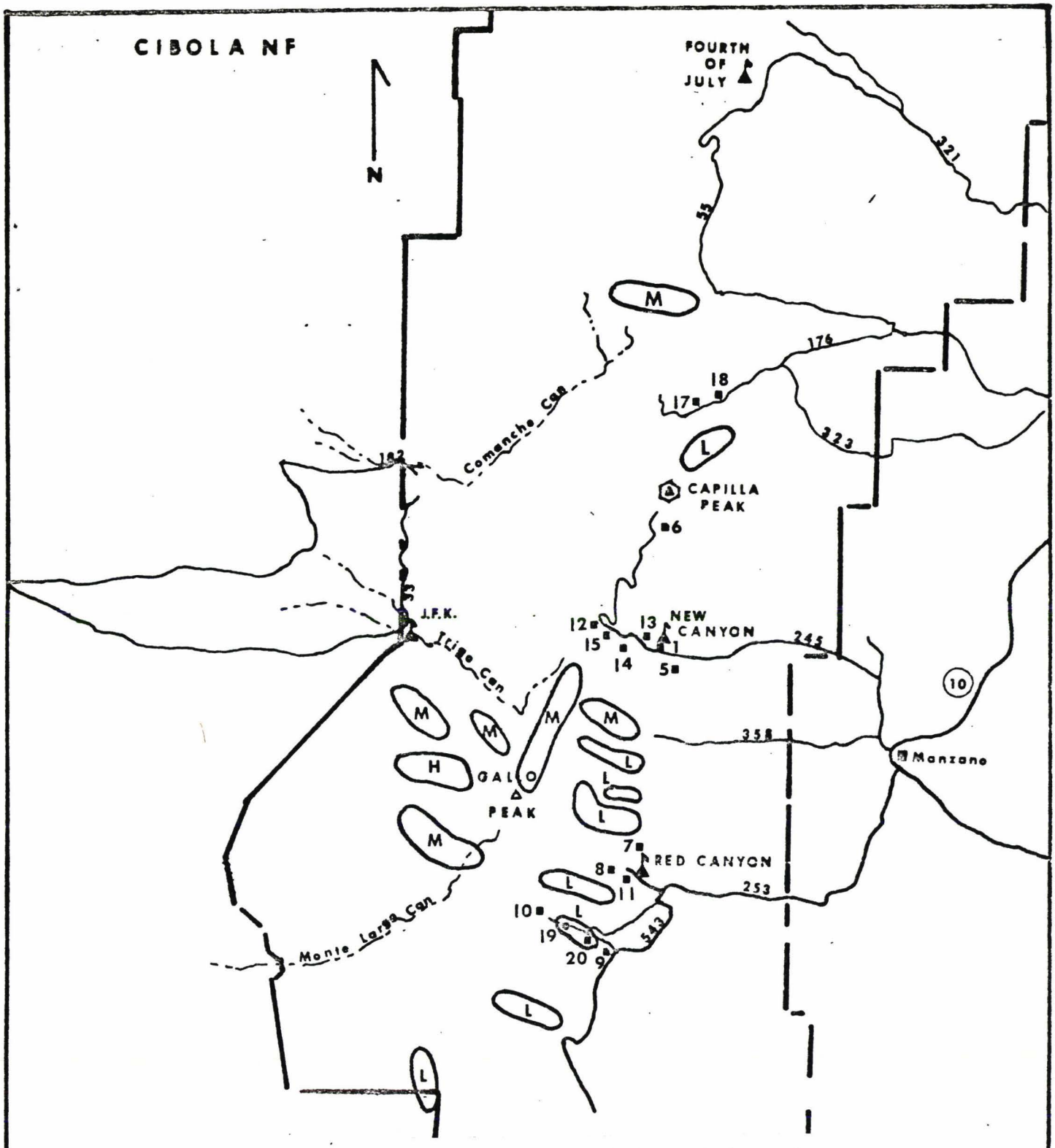


Fig. 21--Western spruce budworm infestation, Manzano Entomological Unit, Cibola NF, 1978.

Legend

Evaluation Cluster Locations	■ 10
Defoliation intensity	
Light	L
Moderate	M
Heavy	H

scale 0 1 mile

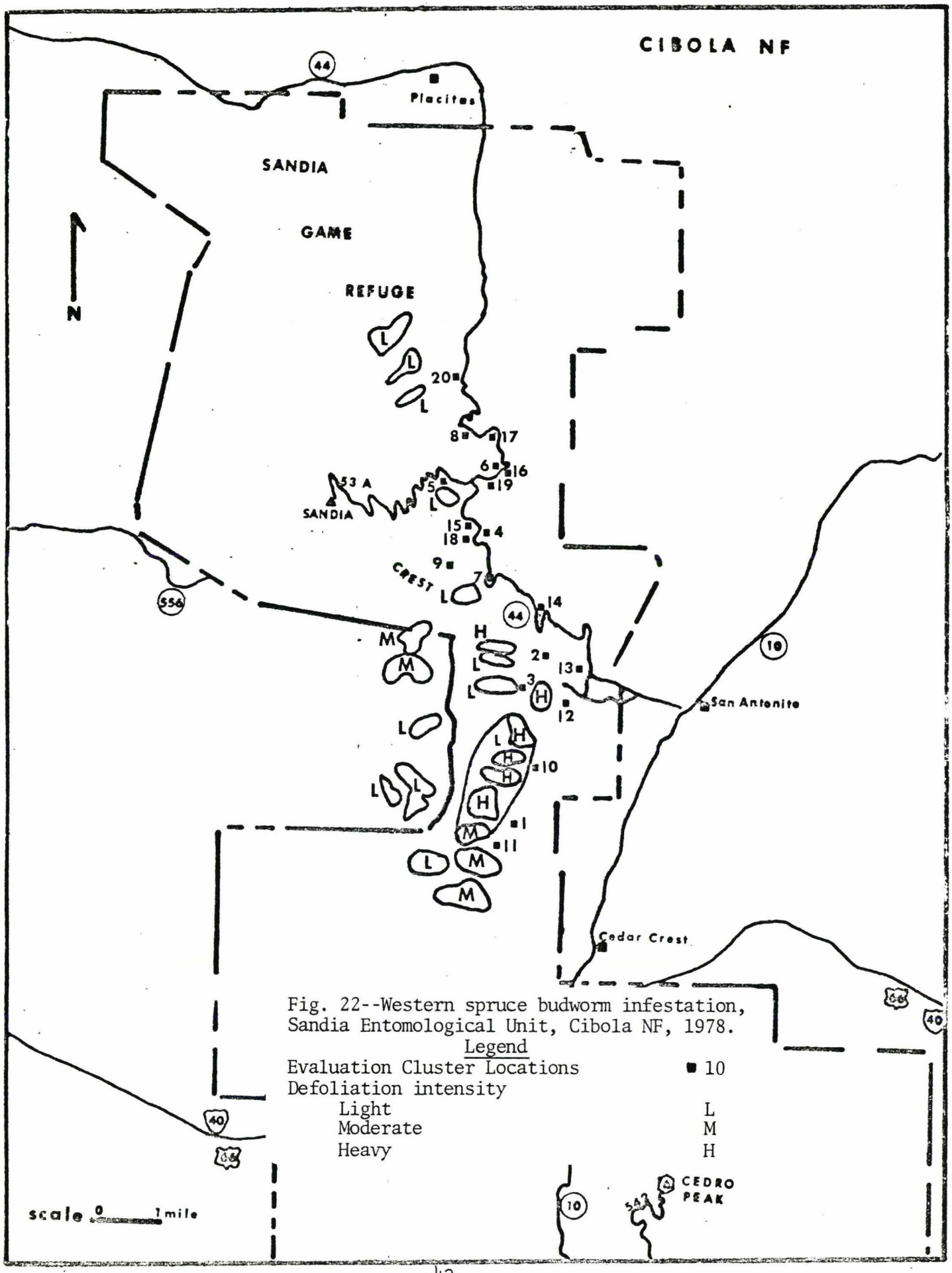


Fig. 22--Western spruce budworm infestation, Sandia Entomological Unit, Cibola NF, 1978.

Legend

Evaluation Cluster Locations	■ 10
Defoliation intensity	
Light	L
Moderate	M
Heavy	H

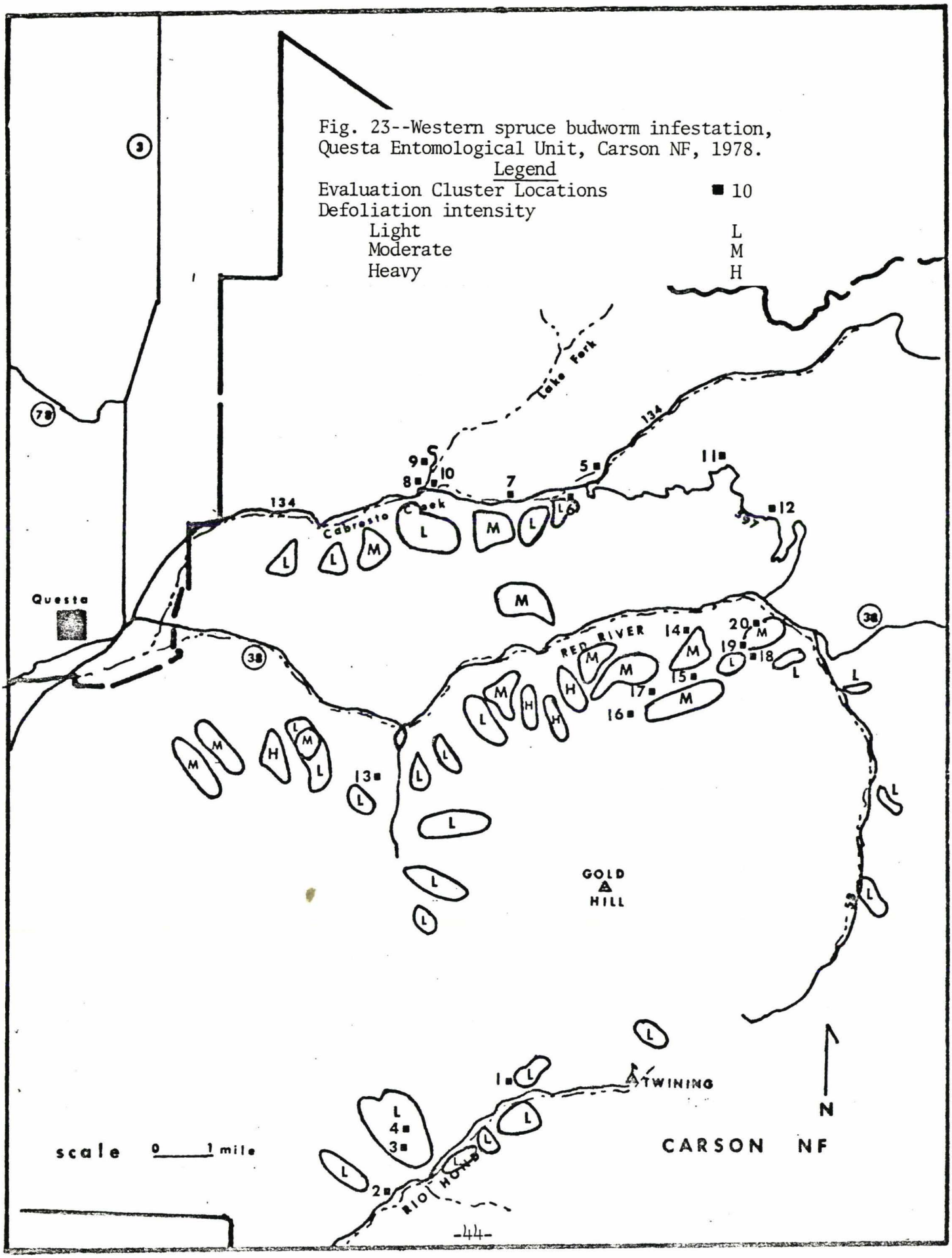


Fig. 23--Western spruce budworm infestation,
Questa Entomological Unit, Carson NF, 1978.
Legend
Evaluation Cluster Locations ■ 10
Defoliation intensity
Light L
Moderate M
Heavy H
Lake Fork
134
Cabresto Creek
Questa
RED RIVER
GOLD HILL
TWINING
CARSON NF
N
scale 0 1 mile

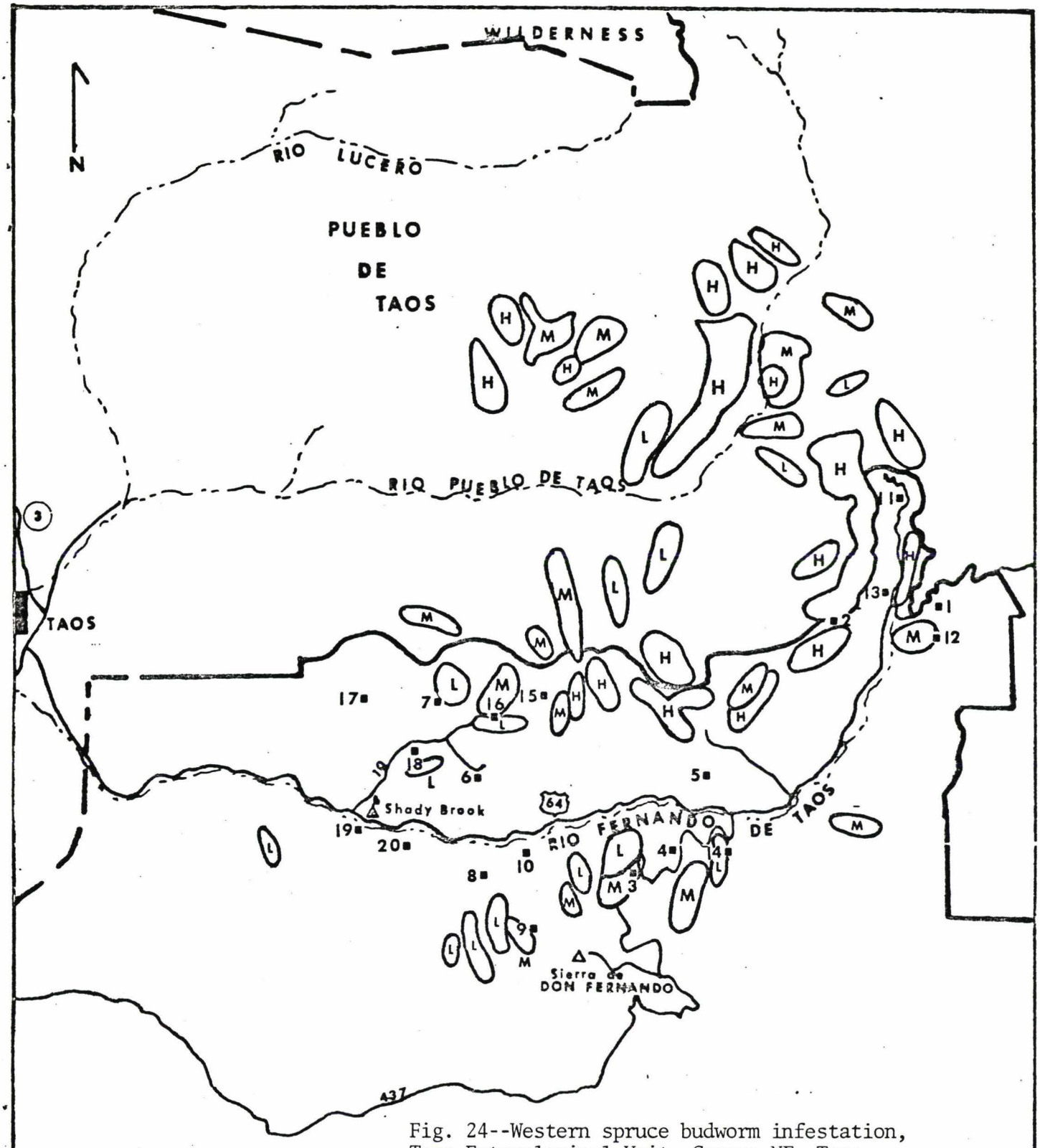


Fig. 24--Western spruce budworm infestation, Taos Entomological Unit, Carson NF; Taos Pueblo, 1978.

Legend

Evaluation Cluster Locations	■ 10
Defoliation intensity	
Light	L
Moderate	M
Heavy	H